UNIVERSITY OF CALIFORNIA
DEC 1 1958

NUCLEAR SCIENCE ABSTRACTS

October 31, 1958

ENGINEERING
DEC 4 1958
LIBRARY

Volume 12 Number 20 SUPPLEMENT
Abstracts 14471 - 15184

UNITED STATES ATOMIC ENERGY COMMISSION
Technical Information Service Extension, Oak Ridge, Tennessee

USAEC DEPOSITORY LIBRARIES

The libraries listed below maintain collections of unclassified U. S. Atomic Energy Commission reports for reference use by the general public. These depository collections are conveniently organized, and staff members of the libraries will assist requesters in the use of the collections. All the libraries have facilities for making photocopies of reports that are not more conveniently available in printed form from the Office of Technical Services. Canadian reports in the AECL series and currently issued British reports in the AERE and IG series are also available at the Libraries listed below. More complete sets of older British reports are available at those libraries identified with an asterisk (*).

ALABAMA
- Auburn, Alabama Polytechnic Institute Library
- Birmingham, Birmingham Public Library

ARIZONA
- Tucson, University of Arizona Library

ARKANSAS
- Fayetteville, University of Arkansas Library

CALIFORNIA
- *Berkeley, University of California General Library
- Los Angeles, University of California Library
- Menlo Park, Stanford Research Institute
- San Diego, San Diego Public Library

COLORADO
- Denver, Denver Public Library

CONNECTICUT
- New Haven, Yale University Library

DELAWARE
- Newark, University of Delaware Library

DISTRICT OF COLUMBIA
- Washington, Library of Congress

FLORIDA
- Coral Gables, University of Miami Library
- Gainesville, University of Florida Engineering Sciences Library

GEORGIA
- Atlanta, Georgia Institute of Technology Library

ILLINOIS
- *Chicago, John Crerar Library
- Chicago, University of Chicago Library
- Evanston, Northwestern University Library
- Urbana, University of Illinois Library

INDIANA
- Indianapolis, Indianapolis Public Library
- Lafayette, Purdue University Library

IOWA
- Ames, Iowa State College Library

KANSAS
- Manhattan, Kansas State College Library

KENTUCKY
- Lexington, University of Kentucky Library
- Louisville, University of Louisville Library

LOUISIANA
- Baton Rouge, Louisiana State University Library
- New Orleans, Tulane University Library

MARYLAND
- Baltimore, Johns Hopkins University Library
- College Park, University of Maryland Engineering and Physical Sciences Library

MASSACHUSETTS
- Cambridge, Harvard University Library
- Cambridge, Massachusetts Institute of Technology Library

MICHIGAN
- Ann Arbor, University of Michigan Library
- Detroit, Detroit Public Library

MINNESOTA
- Minneapolis, University of Minnesota Library

MISSOURI
- Kansas City, Linda Hall Library
- Rolla, The University of Missouri School of Mines and Metallurgy Library
- St. Louis, Washington University Library

NEW JERSEY
- Princeton, Princeton University Library

NEW MEXICO
- Albuquerque, University of New Mexico Library

NEW YORK
- Buffalo, Lockwood Memorial Library
- Ithaca, Cornell University Library
- New York, Atomic Industrial Forum
- New York, Columbia University Library
- *New York, New York Public Library
- Rochester, University of Rochester Library
- Schenectady, Union College Library
- Troy, Rensselaer Polytechnic Institute Library

NORTH CAROLINA
- Charlotte, Charlotte and Mecklenburg County Public Library
- *Durham, Duke University Library
- Raleigh, North Carolina State College Library

OHIO
- Cincinnati, University of Cincinnati Library
- Cleveland, Cleveland Public Library
- Columbus, Ohio State University Library
- Toledo, University of Toledo Library
- Youngstown, Youngstown University Library

OKLAHOMA
- Stillwater, Oklahoma State University Library

OREGON
- Corvallis, Oregon State College Library
- Portland, Portland Public Library

PENNSYLVANIA
- Philadelphia, University of Pennsylvania Library
- Pittsburgh, Carnegie Library of Pittsburgh
- University Park, Pennsylvania State University, Pattee Library

PUERTO RICO
- Rio Piedras, University of Puerto Rico, Main Library

RHODE ISLAND
- Providence, Brown University Library

SOUTH CAROLINA
- Columbia, University of South Carolina, McKissick Memorial Library

TENNESSEE
- Knoxville, University of Tennessee Library
- Memphis, Memphis Public Library
- Nashville, Joint University Libraries

TEXAS
- Austin, University of Texas Library
- College Station, Agricultural and Mechanical College of Texas Library
- Dallas, Southern Methodist University Library
- Houston, The Rice Institute Library
- San Antonio, San Antonio Public Library

UTAH
- Salt Lake City, University of Utah Library

VIRGINIA
- Blacksburg, Virginia Polytechnic Institute Library
- Charlottesville, University of Virginia, Alderman Library

WASHINGTON
- Pullman, State College of Washington Library
- Seattle, University of Washington Library

WEST VIRGINIA
- Morgantown, West Virginia University Library

WISCONSIN
- Madison, University of Wisconsin Library
- Milwaukee, Milwaukee Public Library

WYOMING
- Laramie, University of Wyoming Library

SCOPE

Nuclea
neers
as pro
covers
Atomic
pears
niver
scienti

INDEX

Each i
Semian
clude
listing
number
No. 24

AVAILA

NSA is
cording
or by
the Su
nation

Chan
addres
search
tion.
exchan

Inqui
of addr
Techni
P. O.

NEW N

NSA ha
Data i
the ex
The an
lists o
Nation

Othe
momen
annual
began
also i
which
Nuclea
Nuclea
Data c
sibly a
Vol. 1

The
in bind
prices
used i

NUCLEAR SCIENCE ABSTRACTS

A Publication of the United States Atomic Energy Commission Technical Information Service.

SCOPE

Nuclear Science Abstracts (NSA) is intended to serve scientists and engineers working in the field of atomic energy by abstracting as completely and as promptly as possible the literature of nuclear science and engineering. It covers not only unclassified and declassified research reports of the U. S. Atomic Energy Commission and its contractors, but also material that appears in research reports of other U. S. and foreign government agencies, universities, and industrial research organizations and in the technical and scientific journals.

INDEXES

Each issue of *NSA* is indexed by personal author and by report number. Semiannual and annual index issues are prepared for each volume and include subject, corporate and personal author, and report number indexes, listing the availability of all USAEC reports abstracted. A cumulated report number, author, and subject index to Vols. 1 through 4 was issued as Vol. 4, No. 24B, Dec. 30, 1950.

AVAILABILITY

NSA is issued twice a month and is available in single copies (priced according to the number of pages they contain, plus postage on foreign orders) or by subscription ($12.00 a year domestic, $15.00 a year foreign) from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Change of address notices for subscriptions should be sent to the above address. *NSA* is also available on an exchange basis to universities, research institutions, industrial firms, and publishers of scientific information. The USAEC invites inquiries from such organizations interested in exchanging publications.

Inquiries about exchanges and other official distribution, as well as change of address notices for official and exchange recipients, should be sent to the Technical Information Service Extension, U. S. Atomic Energy Commission, P. O. Box 62, Oak Ridge, Tennessee.

NEW NUCLEAR DATA

NSA has in the past carried in issues 6B, 12B, and 18B lists of New Nuclear Data in which experimental results were displayed in tabular form and, with the exception of Vol. 11 (1957), in issue 24B carried an annual cumulation. The annual cumulation for 1957 was issued as a separate publication. These lists of New Nuclear Data were compiled by the Nuclear Data Group of the National Research Council, Washington 25, D. C.

Other current data on radioactivity, nuclear energy levels, reactions, moments, etc., were also supplied by that group on 3×5 inch cards on an annual subscription basis. Beginning in January 1958 the Nuclear Data Group began issuing $8\frac{1}{2} \times 11$ inch Nuclear Data Sheets which replace the cards and also incorporate the table "Radioactivity, Levels, Abundances, Moments," which has comprised the greater portion of the New Nuclear Data issues of *Nuclear Science Abstracts*. For this reason the quarterly issues of New Nuclear Data have been discontinued. The 1958 cumulation of New Nuclear Data consisting of tables previously listed in the quarterly issues, and possibly additional tables, will appear as issue 24B of *Nuclear Science Abstracts* Vol. 12.

The Nuclear Data Sheets are available in a light-weight stock for insertion in binders and a heavy-weight stock for drawer filing. Annual subscription prices are $15 for the light and $18 for the heavy stock. Parcel post will be used in the U.S.A., printed matter mail elsewhere. Order from the Publications Office, National Academy of Sciences-National Research Council, 2101 Constitution Avenue, Washington 25, D. C.

AVAILABILITY OF REPORTS ABSTRACTED

USAEC reports (as identified in the Numerical Index of Reports) are available free of charge to U. S. Government agencies and their contractors from the Technical Information Service Extension, Oak Ridge, Tennessee. Other requesters should obtain reports as described below.

AEC Reports The Office of Technical Services, Department of Commerce, Washington 25, D. C., is the sales agency for AEC unclassified reports, although a small number of other AEC unclassified reports are available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. The sales availability of each report is given in the abstract. The symbol "OTS" indicates availability from the Office of Technical Services, and "ph" and "mf" indicate photostat and microfilm copy. The form is not specified if the report is available in printed form. Sales availability is also given in the semiannual and annual Numerical Index of Reports.

Price lists of the Office of Technical Services and of the Superintendent of Documents may be obtained upon request from these sales agencies. Reports should be ordered by report number and title. A check or money order made payable to the Treasurer of the United States should accompany each order. Foreign purchasers of reports, other than those in Canada and Mexico, should include an additional amount for postage, according to the scale that four pages approximate one ounce. It is the purchaser's responsibility to compute the necessary postage since rates vary for different countries.

The USAEC has made contractual arrangements for the sale of microcopy of AEC reports from the Microcard Foundation, P. O. Box 2145, Madison 5, Wisconsin, and the Readex Microprint Corporation, 115 University Place, New York 3, N. Y.

Many reports abstracted in *NSA* may be published subsequently in scientific and technical journals and books. The pertinent publication information is listed in the semiannual and annual cumulations of the Numerical Index of Reports and in the *Cumulated Numerical List of Available Unclassified U. S. Atomic Energy Commission Reports* (TID-4000).

USAEC reports also may be consulted at the AEC depository libraries listed on the inside front cover. Collections of AEC reports outside the United States have been established and are being maintained at those addresses listed on the inside back cover.

Non - AEC Reports Reports prepared by organizations not under contract to the USAEC (as identified in the Numerical Index of Reports) should be requested from the issuing agency indicated in the abstract of the report. Requests for reports abstracted under NP numbers should give title and author since these numbers are assigned by the USAEC and may not be known by the originating agency. British and Canadian reports are available for examination at the AEC depository libraries. British reports can also be purchased from the British Information Service (identified in the abstract as BIS), 30 Rockefeller Plaza, New York, N. Y. Canadian reports (AECL series) can be purchased from the Scientific Document Distribution Office, Atomic Energy of Canada Limited, Chalk River, Ontario, Canada.

Translations Copies of translations prepared by the USAEC and its contractors are available from the Special Libraries Association Translation Center, John Crerar Library, 86 E. Randolph Street, Chicago 1, Illinois.

U. S. Patents Copies of U. S. patents are available from the U. S. Patent Office, Department of Commerce, Washington 25, D. C., for $0.25 per copy.

The printing of this publication has been approved by the Director of the Bureau of the Budget, July 30, 1957.

CONTENTS

Volume 12, Number 20 Supplement, October 31, 1958

Category	Abstract	Page
GENERAL	14471	1735
Atomic Bombs and Warfare	14471	1735
Atomic Power	14472	1735
Research Programs	14480	1736
BIOLOGY AND MEDICINE	14484	1737
Radiation Effects	14488	1738
Radiation Hazards and Protection	14513	1746
Radiography	14539	1752
Radiotherapy	14542	1752
Toxicology Studies	14551	1754
Tracer Applications	14553	1755
Waste Disposal	14604	1768
CHEMISTRY	14605	1768
Analytical Procedures	14615	1770
Crystallography and Crystal Structure	14627	1773
Deuterium and Deuterium Compounds	14628	1773
Fluorine and Fluorine Compounds	14630	1773
Graphite	14636	1775
Laboratories and Equipment	14639	1776
Radiation Chemistry	14645	1777
Radiation Effects	14656	1779
Rare Earths and Rare-earth Compounds	14667	1781
Separation Procedures	14668	1781
Syntheses	14716	1791
Tracer Applications	14717	1791
Transuranic Elements and Compounds	14719	1792
Uranium and Uranium Compounds	14726	1793
Waste Disposal	14744	1798
ENGINEERING	14754	1800
Heat Transfer and Fluid Flow	14755	1800
Pumps	14758	1801
Tracer Applications	14760	1801
Waste Disposal	14761	1801
MINERALOGY, METALLURGY, AND CERAMICS		
Ceramics and Refractories	14764	1802
MINERALOGY, METALLURGY, AND CERAMICS (cont'd)		
Corrosion	14767	1803
Geology and Mineralogy	14770	1803
Metals and Metallurgy	14809	1813
Tracer Applications	14838	1819
PHYSICS	14839	1819
Astrophysics	14843	1820
Crystallography and Crystal Structure	14844	1820
Electrical Discharge	14845	1820
Electrons	14898	1829
Gases	14900	1829
Isotopes	14901	1830
Isotope Separation	14904	1830
Mass Spectrography	14905	1830
Mathematics	14906	1831
Measuring Instruments and Techniques	14911	1832
Mesons	14936	1838
Meteorology	14939	1838
Molecular Properties	14942	1839
Neutrons	14943	1839
Nuclear Physics	14959	1842
Nuclear Properties	14965	1844
Nuclear Reactors	14980	1847
Nuclear Transformation	15130	1874
Particle Accelerators	15142	1876
Radiation Absorption and Scattering	15149	1877
Radiation Effects	15152	1878
Radioactivity	15164	1881
Rare Earths and Rare-earth Compounds	15171	1882
Shielding		1882
Spectroscopy	15172	1882
Theoretical Physics	15174	1883
Tracer Applications	15175	1883
Uranium and Uranium Compounds	15176	1883
PERSONAL AUTHOR INDEX		INDEX-1
NUMERICAL INDEX OF REPORTS		INDEX-8

NUCLEAR SCIENCE ABSTRACTS

Volume 12 Number 20 October 31, 1958

SUPPLEMENT

This special issue covers the United States papers prepared for presentation at the Second United Nations Conference on the Peaceful Uses of Atomic Energy.

GENERAL

Atomic Bombs and Warfare

14471 A/CONF.15/P/2259
American Machine and Foundry Co., New York.
INTERNATIONAL COLLABORATION ON STANDARDS IN THE FIELD OF NUCLEAR ENERGY. Morehead Patterson. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The importance of nuclear standards is discussed. A brief review of the international collaboration in this field is given. The proposal is made to let the International Organization for Standardization (ISO) coordinate the efforts from other groups. (W.D.M.)

Atomic Power

14472 A/CONF.15/P/443
Stanford Research Inst., Menlo Park, Calif.
NUCLEAR ENERGY FOR INDUSTRIAL HEAT. Richard R. Tarrice. 29p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Some of the factors involved in the production of nuclear heat for industry are examined, and the industrial nuclear heat potential in the United States and other industrialized nations is discussed. The status of process heat reactor design is reviewed and economically evaluated. (D.E.B.)

14473 A/CONF.15/P/833
Martin Co., Baltimore.
POWER FROM RADIOISOTOPES. Kenneth P. Johnson. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The use of radioisotopes as a source of power is discussed. Two power ranges, ten and 500 watts, are explored. The selection of fuel is determined by power density in realizable form, cost, availability, shielding, and biological hazards considerations. A list of feasible radioisotopes is presented based on the above considerations. These radioisotope fuels are divided into the two categories of reactor produced and fission products. Particular emphasis is placed on practical engineering problems to be considered in fuel selection such as minimization of biological hazards and radiological shielding requirements. Fuel element design and fabrication is discussed to illustrate realizable fuel forms and manufacturing techniques which might be employed. Radioisotope availability at the present time is a major consideration in view of the limited number of radioisotope separation and handling facilities. Future possibilities in the area of cost and availability are explored in the light of rising demand for radioisotope fuels. Power conversion systems are discussed with respect to the two levels of power being explored. (auth)

14474 A/CONF.15/P/1023
Society of Naval Architects and Marine Engineers, New York.
DESIGN CONSIDERATIONS IN NUCLEAR MERCHANT SHIPS. R. P. Godwin and D. L. Worf. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A comprehensive survey of the safeguards considerations developed and applied in the United States nuclear powered merchant ship program is presented. A brief review of the major design factors of the first ship, N.S. SAVANNAH, is included to provide perspective for the further development of the safeguards aspects. Health and safety features, including American philosophy and design practice, are presented for the vessel and the reactor, with particular attention being given to containment, shielding, waste disposal, instrumentation, and control systems. The health physics program for the first ship is detailed, including the establishment of radiation limits for passengers and crew, shipboard monitoring systems, and provisions and facilities for analytical services. Manning requirements and the special training program for the crew of the first ship are also outlined. Areas of additional importance include studies of meteorology, harbor factors, and an evaluation of credible emergencies are described together with shore facilities. A comparison of the safety of the ship reactor to land-based plants, a preview of the operational phases of this project, and a discussion of international interests in the American ship program are included in the summary. (auth)

14475 A/CONF.15/P/1043
Michigan. Univ., Ann Arbor. Michigan Memorial-Phoenix Project.
A GENERALIZED ATOMIC ENERGY PROGRAM.

G. Hoyt Whipple and William Kerr. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The steps that are considered important in evolving an atomic energy program are outlined. The type of information needed and the sources of such information are indicated. In most cases the factor which will limit the speed at which the program can be carried out is the supply of men trained in the various nuclear disciplines. The types and numbers of individuals with special training that are needed for a successful atomic energy program are suggested, and sources of such training in the United States are given. Not all of the potential benefits of atomic energy are of equal value to every country, and in some circumstances extensive preparatory work must be done before these benefits can be realized. The contributions that atomic energy can be expected to make to the development of a country are discussed to show that in some cases these benefits cannot be expected to play an important, immediate part in a country's development, and, in fact, may slow the over-all development by diverting limited resources from efforts of greater importance. Schedules for several development programs are given as a guide to planning, and the special problems that may introduce delays are discussed. Where both time and resources are limited, the planning of a realistic atomic energy program requires careful attention to the step by step realization of limited objectives. (auth)

14476 A/CONF.15/P/1076

Bechtel Corp., San Francisco and [Division of Reactor Development.]

HIGHLIGHTS OF NUCLEAR POWER DEVELOPMENT IN THE UNITED STATES. W. Kenneth Davis and U. M. Staebler. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The domestic and international objectives of the U. S. Nuclear Power Program are defined with respect to scope and goals. The broad schedule for attaining these objectives is presented. The over-all problems in the achievement of economic and safe nuclear power are outlined and discussed. The important characteristics of various classes of reactors with respect to these problems and goals are discussed. The programs established by the U.S. to solve these problems are presented along with an evaluation of the progress to date and the steps necessary for the future. The interrelationships between government and industry in carrying out these programs are considered. The uses of energy in the U.S. and the resources of conventional fuels are considered in relationship to the long range potentialities of nuclear power not only for the generation of electric power but for providing for other major energy requirements as well. (auth)

14477 A/CONF.15/P/2161

Edison Electric Inst., New York.

NUCLEAR POWER PROGRAM OF INVESTOR-OWNED ELECTRIC UTILITY COMPANIES IN THE UNITED STATES. Elmer L. Lindseth. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The role of the investor-owned electric utility companies in the United States in the nuclear power program is discussed. A review is given of the various power projects under construction, operating, designed, and proposed. (W.D.M.)

14478 A/CONF.15/P/2163

Nuclear Products-Erco Div., ACF Industries, Inc., Washington, D. C.

THE ECONOMIC SETTING FOR NUCLEAR POWER AND HEAT DEVELOPMENT. Karl M. Mayer. 53p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Results of economic studies of the future of nuclear power which have been completed in the 1955-1958 period are reported. The results of the economic studies are intended to be of use to government leaders in developing nuclear power programs, individual industries in planning for future expansion, reactor manufacturers in evaluating future nuclear market possibilities, and individual reactor designers in providing data on the needs of the market which must be satisfied if reactors are to be sold in quantity in the future. The scope is world-wide and the underlying studies of the future markets for nuclear power cover the 1960-1980 period. Past and projected consumption of power in 152 countries and national subdivisions was studied and the results are reported. (auth)

14479 A/CONF.15/P/2178

Illinois Inst. of Tech., Chicago. Armour Research Foundation.

A NEW APPROACH TO HEAT AND POWER GENERATION FROM CONTAINED NUCLEAR EXPLOSIONS. F. B. Porzel. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The feasibility of using nuclear explosions as a heat source for power and for controlled excavations is discussed. Some basic hydrodynamic concepts regarding the growth of any point-source underground explosion are presented. (W.D.M.)

Research Programs

14480 A/CONF.15/P/1031

Oak Ridge Inst. of Nuclear Studies, Inc., Tenn.

PROBLEMS IN THE TRAINING OF INTERNATIONAL STUDENTS IN RADIOISOTOPE TECHNIQUES. Ralph T. Overman and Lawrence K. Akers. 6p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In the ten years that the Special Training Division of the Oak Ridge Institute of Nuclear Studies has conducted its intensive radioisotope-techniques courses, approximately 350 nationals of countries other than the United States have participated. This special training has permitted the foreign participants to return to their various countries and initiate or continue the use of radioisotopes in their scientific programs. Many of these participants have also begun similar training programs in their own countries; these have ranged from informal assistance to other scientists to the establishment of both university-type and short-term courses. Typical programs that have been carried out by various scientists, following their Oak Ridge training period, are described. In addition to presenting the training courses, the special Training Division staff has assisted in the organization of a Spanish Language Nuclear Training Center at the University of Puerto Rico, and in the establishment of a formal training program at the American University of Beirut. Assistance has also been given to Egyptian nationals in developing training programs. Some of the problems involved in working

with scientists of varying cultural and language backgrounds are discussed. A list of equipment for a general intensive training program is included, and a typical basic curriculum that can be modified to meet the needs of different groups is described. Suggestions are made for the planning of these training programs so as to minimize the difficulties that may arise at the time they begin. The considerations apply to reactor training programs as well as to radioisotope training programs. (auth)

14481 A/CONF.15/P/1042
Division of Biology and Medicine, AEC.
THE CONTRIBUTION OF THE UNITED STATES ATOMIC ENERGY COMMISSION TO THE CULTIVATION OF OUR INTELLECTUAL RESOURCES. C. W. Shilling. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The U. S. Atomic Energy Commission is supporting an educational and training program which will materially help to alleviate the shortage of scientists trained in the nuclear field and will more nearly ensure proper future development. This program is briefly outlined. (auth)

14482 A/CONF.15/P/1787
Division of International Affairs, AEC.
UNITED STATES TRAINING OF FOREIGN NATIONALS IN NUCLEAR SCIENCE AND ENGINEERING. Jesse D. Perkinson, Jr. 4p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

It is recognized that education and training of required personnel is the paramount goal that must be accomplished in order that development of nuclear science and engineering for peaceful purposes can be attained. The United States Atomic Energy Commission, in recognition of this urgent need, has initiated several training programs to meet specific needs. The Commission follows a primary policy, that nuclear education of the type that can be provided by universities and industries, should not be an activity of the Commission. In view of this fact, a strong program has been initiated for the development of nuclear educational facilities at universities. It is recognized, however, that the most advanced and specialized aspects of training and education cannot be offered by these institutions and that the national laboratory facilities must be called upon for this kind of educational program. These nuclear educational opportunities which are open to both United States citizens and foreign nationals include formal courses administered and partially financed by the Commission, and individual training arranged at our national laboratories. Among the formal courses is a world famous short course in Radioisotopes Techniques, conducted by the Oak Ridge Institute of Nuclear Studies for the last 10 years. Due to the number of requests from many different countries, the Commission approved, in 1954, the admittance of foreign scientists under a quota. This quota is now 30% of the total enrollment. The sessions are of four weeks duration and are conducted six times a year. Training is provided in the principal techniques of handling and using radioisotopes in research and in industrial applications. Approximately 300 scientists from 46 foreign nations, and about 2,500 United States scientists have been trained. A second formal program, The International School of Nuclear Science and Engineering was established in 1955 at Argonne National Laboratory. Through 1957, approximately 300 foreign participants from 43 countries and about 85 United States participants have completed this course. Applications for admission to the school are considered by a selection committee in terms of the applicant's academic qualifications, working experience and professional interest. This course offers a broad background in nuclear science and engineering. Specialization in a particular field requires additional training and experience. In line with Commission policy, that part of the training which can be accomplished outside of Argonne National Laboratory is conducted by two universities. In order to meet the educational needs of Latin American countries, the Commission has contracted with the University of Puerto Rico for the establishment of a nuclear center which offers several formal courses and research opportunities. The courses are conducted in Spanish and are designed to meet the needs of students and scientists from the Republics of Latin America. At present, the courses being offered include a graduate level, one year program in nuclear engineering; a four weeks radioisotope course, given every second month; a graduate level, one year program in radiological physics; and several short courses in medical aspects of nuclear science, such as the use of radioisotopes in basic medical science, clinical utilization of radioisotopes, radiation health, and radiotherapy and cytology. In addition to these formal courses, students may be accepted for varying periods of time as research participants. At a national laboratory, three additional formal courses will be available for foreign personnel. These are reactor hazards evaluation, reactor supervision and monitoring techniques. The other major effort of the Commission in training of foreign nationals consists of securing individual training programs at our national laboratories, universities, or other private facilities. These arrangements are made to conform strictly with the individual's desires, abilities, and needs. In 1957, the Commission arranged for approximately 500 training programs of this type for foreign nationals. Another expressed interest of the Commission is in the training of personnel related to international and regional agencies, such as the International Atomic Energy Agency, Euratom, OEEC, and OAS. (auth)

14483 A/CONF.15/P/2392
Massachusetts Inst. of Tech., Cambridge.
NUCLEAR ENGINEERING AND SCIENCE EDUCATION IN UNITED STATES UNIVERSITIES. Walter G. Whitman. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Nuclear Engineering is a field of graduate school specialization for students from many different professional trainings who will develop the ability to apply their own professional talents to the advancement of nuclear enterprises. The most critical problem is a competent and inspired faculty, drawn from several professions, and dedicated to meeting the educational challenge. The program becomes expensive, especially if good research facilities are provided at the university, and strong financial support from government seems essential. In the present stage of development, nuclear engineering education is highly experimental. (auth)

BIOLOGY AND MEDICINE

14484 A/CONF.15/P/799
Illinois. Univ., Urbana.
THE EFFECT OF IRRADIATION STERILIZATION ON

THE NUTRITIVE VALUE OF THE PROTEIN AND ENERGY COMPONENTS OF FOODS. B. Connor Johnson, V. C. Metta, and W. S. Tsien. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The effect of gamma ray irradiation at levels of 3 to 6 million r on the nutritive value of various foods was studied in the rat. The data indicate that irradiation at 3 million r has little harmful effect on the digestibility or the biological value of the proteins of beef, beans, corn, or wheat. Milk and pea proteins were somewhat more sensitive, the biological value decreasing by 8% due to 3 million r irradiation. Generally, however, the irradiation effects on the nutritive value of the protein are not significantly different from the effects of heat sterilization. Amino acid analyses by the Moore-Stein column method indicate that at 3 to 6 million r the sulfur amino acids were found to be very sensitive to irradiation (10 to 20% destruction). In milk irradiated at 10 million r, however, glutamic acid was most unstable, being 49% destroyed, while methionine, serine, and histidine were 30% destroyed. Irradiation sterilization has no effect whatever on the metabolizable energy contributed by the energonic components of the diet. Long-term feeding experiments have confirmed the fact that irradiation-sterilized beef and flour are satisfactory for optimum growth and maintenance of female rats for periods of over 18 months. (auth)

14485 A/CONF.15/P/807

Michael Reese Hospital, Chicago and Quartermaster Food and Container Inst., Chicago.

THE PROBLEM OF INDUCED RADIOACTIVITY IN THE USE OF HIGH ENERGY ELECTRONS (25 Mev) FOR STERILIZATION AND CHEMICAL PROCESSING. J. Ovadia, F. Heinmets, and A. Herschman. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In this work, 25 Mev electrons from a linear electron accelerator, were used to irradiate various salt solutions and food products, at a dose rate varying from 0.7 to 1.1×10^6 rad/min. Solutions of elements with an atomic number ranging from Z = 6 to Z = 53 were chosen which led to conveniently measured radioactivities by positron emission with simple decay schemes which could be easily interpreted. The relative yields in microcurie per gram of irradiated substance per 10^6 rad of high energy electrons are compared to corresponding data reported in the literature for 18 and 22 Mev x-rays from betatrons. The sharp increase in photodisintegration yield with increasing atomic number observed with x-rays was also noted; the yields with 25 Mev electrons are, however, larger by two orders of magnitude. An approximate theoretical calculation of the activity to be expected on the assumption that it arises from (γ,n) reactions of the bremsstrahlen produced in the sample by the high energy electrons was carried out. The experimental results are compared with this theoretical calculation. From a practical point of view, it is convenient to differentiate between short-lived isotopes which create problems in processing and storage and long-lived isotopes which create health hazards in the final product. The significance of the experimental results with respect to both of these problems is discussed. (auth)

14486 A/CONF.15/P/843

California. Univ., Berkeley. Radiation Lab.

EFFECT OF DEUTERIUM OXIDE (HEAVY WATER) ON BIOLOGICAL SYSTEMS. E. L. Bennett, M. Calvin, O. Holm-Hansen, A. M. Hughes, K. K. Lonberg-Holm, V. Moses, and B. M. Tolbert. 9p. (UCRL-3981). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The effects of deuterium on growth, proton or deuteron uptake, and photosynthesis of algae are discussed. The effect of deuterium in prolonging the life of mice inoculated with tumors or leukemia, and the production of sterility in mice drinking D_2O are also discussed. (T.R.H.)

14487 A/CONF.15/P/2246

California. Univ., Berkeley. Radiation Lab.

PHOTOSYNTHESIS. Melvin Calvin, J. M. Anderson, James A. Bassham, U. Blass, O. Holm-Hansen, Vivian Moses, N. G. Pon, P. B. Sogo, and Gordon Tollin. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The oxygen pathway in photosynthesis was studied using O^{18} and an activation technique. High specific activity tritiated water was used to trace the path of hydrogen. These studies and carbon-14 studies of photosynthesis and electron spin resonance studies of primary quantum conversion in photosynthesis are summarized. (T.R.H.)

Radiation Effects

14488 A/CONF.15/P/806

American Meat Inst. Foundation, Chicago. and Chicago. Univ.

CHEMICAL CHANGES IN MEAT INDUCED BY GAMMA IRRADIATION. D. M. Doty, O. F. Batzer, J. B. Fox, Jr., R. A. Sliwinski, L. A. Witting, and B. S. Schweigert. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

During the gamma irradiation of raw beef, the pH, hydrogen sulfide, methyl mercaptan, and carbonyls increase; glutathione and glycogen decrease; and changes occur in the chemical nature of the pigments present. The nature and extent of most of these chemical changes are influenced by the fat content of the meat, the time and temperature of storage prior to irradiation, the irradiation dosage, and the storage time and temperature after irradiation. The exact relationship of these chemical changes to changes in odor and flavor of cooked meat has not been established. However, these chemical changes can be measured objectively, and would in many cases logically be expected to influence odor and flavor. (auth)

14489 A/CONF.15/P/815

Minnesota. Univ., Minneapolis.

POST-IRRADIATION MODIFICATION OF INJURY IN BARLEY—ITS BASIC AND APPLIED SIGNIFICANCE. Richard S. Caldecott. 26p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Data are presented on the influence of the water content of seeds on their sensitivity to post-irradiation storage and aerobic hydration as measured by seedling injury and the frequency of chromosomal aberrations and mutations. (C.H.)

14490 A/CONF.15/P/884

Smithsonian Institution, Washington, D. C. and Inter-American Inst. of Agricultural Sciences, Turrialba, Costa Rica.

NONIONIZING RADIANT ENERGY AS A MEDIATING

FACTOR CONTROLLING RADIATION DAMAGE IN PLANTS AND ANIMALS. Robert B. Withrow and C. C. Moh. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Far-red radiant energy from 715 to 940 mμ, at an irradiance of 3000 $\mu w/cm^2$, is capable of potentiating the effect of 100 to 120 r of x-rays on chromatid aberrations in Tradescantia microspores, Vicia faba root tips, and guppy mortality. The action spectrum for the potentiation in Vicia peaks at about 760 mμ. When red energy from 620 to 680 mμ, at an irradiance of 300 $\mu w/cm^2$, was applied to Vicia root tips, either simultaneously with or immediately following the far-red treatment, no increase in aberration frequency was noted. If blue at 436 mμ rather than red is applied at 4000 $\mu w/cm^2$ along with the far-red, there is no effect on potentiation and the results are similar to those secured as if no blue exposure were made. These results indicate that the red is capable of nullifying or reversing the far-red potentiating effect and they may explain the lack of solar irradiation effect and the long-lived activated states observed by previous workers. (auth)

14491 A/CONF.15/P/885

Brookhaven National Lab., Upton, N. Y. and Children's Cancer Research Foundation, Boston.

MECHANISM OF INDUCTION OF MAMMARY NEOPLASMS IN RATS BY RADIATION: RELATION TO DOSE AND OVARIAN STATUS. V. P. Bond, E. P. Cronkite, C. J. Shellabarger, S. W. Lippincott, J. Furth, and R. A. Conard. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In considering the mechanisms of radiation-induced neoplasia, quantitative dose-effect data, and information on the possible influence of tissues other than the target organ are essential. Approximately 400 r of x or gamma radiation to Sprague-Dawley rats has been shown to result in a high incidence of mammary gland neoplasms (adenofibromas, fibroadenomas, adenocarcinomas, fibrosarcomas). Neoplasms appeared as early as 2 months after exposure, and the incidence reached approximately 60% or more by the 10th month. Tumors in non-irradiated animals were extremely rare in this time interval. Co^{60} was less effective than x rays in producing tumors by a factor of 0.8. Dose-dependency studies have shown that the effect is directly proportional to dose between the levels of 25 and 400 r, and that the extrapolated curve passes through zero if the small, natural incidence of tumors is subtracted. Studies on the mechanism of induction of the tumors have shown that ovarian function must be intact for maximal tumor incidence. Above 400 r the incidence fell off with increasing dose, related to radiation-induced depressed ovarian function as indicated by estrus studies and by uterine weight at autopsy. Some tumors showed further conditioning in that on transplantation, growth was optimal only in animals with ovarian hormone present. The conditioning has been shown to hold through two sub-transplants. The dose dependency to low values exhibited by the radiation-induced neoplasms in the present experiments can be considered as evidence for the single hit, somatic mutation theory of cancer induction. The dose dependency of effect obtained, however, was manifest only if the proper hormonal status in the host was maintained. These data are pertinent to the controversial problem of radiation-induced neoplasia, particularly at low dose levels. (auth)

14492 A/CONF.15/P/888

California. Univ., Berkeley. Donner Lab.

HEMATOLOGIC EFFECTS IN MAN OF LOW-LEVEL RADIATION EXPOSURE. R. Lowry Dobson and Mary M. Chupp. 18p. (UCRL-3996). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A significant increase in binucleated lymphocytes in the peripheral blood was observed in normal individuals exposed intermittently and chronically to low-level x and gamma radiation of the order of 0.1 to 0.2 r per week. The average incidence of these cells in a group of eight chronically exposed persons was 5.9 per 50,000 leukocytes; the range was 3.4 to 7.6. The average incidence in a control group of seven persons was 1.4; the range was 0.4 to 2.5. A significant increase in binucleated lymphocytes in the peripheral blood was observed in two normal individuals at different times after they were exposed to a single acute dose of gamma radiation of the order of 2.5 r. Significant hematologic responses were not seen in five other normal individuals after single exposures to gamma radiation in doses less than 2 r. The data presented suggest that peaks in the binucleated lymphocyte response pattern after individual doses of radiation occur within a few days to perhaps 10 days after exposure. In some individuals relatively high levels appear to persist. The binucleated lymphocyte response is not specific to radiation. It is probably related also to physiologic stress. A few measurements made of the desoxyribose nucleic acid (DNA) content of binucleated lymphocytes indicate that these cells contain probably the normal lymphocyte complement of DNA, divided between the two nuclei. (auth)

14493 A/CONF.15/P/891

California. Univ., Los Angeles. School of Medicine.

THE EFFECTS OF IONIZING X-IRRADIATION ON THE ADULT AND IMMATURE MAMMALIAN BRAIN. C. D. Clemente, J. Yamazaki, L. Bennett, R. McFall, and E. H. Maynard. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Data are presented from which it is concluded that the central nervous system is liable to severe damage from ionizing radiations. In general, the adult mammalian brain can withstand higher radiations without the development of neurological signs than the new born brain. In rats an apparent and significant radioresistence in the central nervous system is developed within the first 6 to 8 days of life. Although pathology is sometimes seen in older rats following irradiation, it requires a higher dose than the development of the same signs by head irradiation of the new born. After large dosage irradiation to the heads of adult monkeys, the vital centers in the brain steam (hypothalamus and medulla) seem to be more radiosensitive than other regions in the nervous system. In our experiments this was recognized by neuronal, and neuroglial pathology and by the profound changes in vascular permeability observed in the hypothalamus and medulla following irradiation. A direct explanation of the differences in radiosensitivity of the new born brain and the two week old brain cannot as yet be given. It is possible that there is a significant change in the water content of the nervous system during this period although we have not been able to uncover data along these lines to support this hypothesis. (auth)

14494 A/CONF.15/P/893

Indiana. Univ., Bloomington.

ADVANCES IN RADIATION MUTAGENESIS THROUGH

STUDIES ON DROSOPHILA. H. J. Muller. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The approximately linear relation between radiation dose and induced lethals, known for Drosophila spermatozoa, is now extended to spermatids. Data are included regarding oogonia. The linearity principle has been confirmed for minute structural changes in spermatozoa. The dependence of gross structural changes, as multi-hit events, on about the 1.5 power of the dose, long known for spermatozoa, is now extended to spermatids and late oocytes, for relatively short exposures. However, these stages unlike spermatozoa are found to allow union of broken chromosomes. Therefore, the frequencies are lower for more dispersed exposures of these stages, and the precise dose relation varies with the timing. Part of the dominant and even recessive lethals induced in late oocytes follow the same frequency pattern and therefore are multi-hit events. Yet there is a much lower chance after oocytic than spermatozoan irradiation that two broken ends derived from different hits will unite, hence most such unions are nonreciprocal. The following is the order of decreasing radiation mutability of different stages found by ourselves and others: spermatids, spermatozoa in females, spermatozoa 0 to 1 day before ejaculation, earlier spermatozoa, late oocytes, gonia of either sex. Lethal frequencies for these stages range over approximately an order of magnitude, gross structural changes far more widely. Of potential usefulness is our extension of the principle of marked reduction of radiation mutagenesis by anoxia, known for spermatozoa in adult males, to those in pupal males and in females, to spermatids and to oocytes. In spermatids this reduction is especially marked but the increase caused by substituting oxygen for air is less marked, perhaps because of enzymatic differences. In contrast, the induction of gross structural changes in oocytes, but not in spermatids, is markedly reduced by oxygen post-treatment; it is increased by dehydration. The efficacy of induction of structural changes by treatment of spermatozoa, whether with radiation or chemical mutagens, is correlated with the conditions of sperm utilization and egg production. Improving our perspective on radiation effects, some 800,000 offspring have been scored for spontaneous visible mutations of 13 specific loci. The average point-mutation rate was 0.5 to 1.0 per locus among 10^5 germ cells. Most mutations occurred in peri-fertilization stages. All loci studied mutated from one to nine times. Loci mutating oftener spontaneously also gave more radiation mutations, in other studies. Spectra of individual loci prove similar for spontaneous and induced mutations. Studies on back-mutations also showed similarity of spontaneous and radiation mutations. The doubling dose for back-mutations of forked induced in spermatozoa was several hundred roentgens, similar to that for direct point-mutations induced in gonia at diverse loci. Recent analyses of human mutational load lead to mutation-rate estimates like those earlier based on extrapolations from Drosophila, thus supporting the significance for man of the present studies. (auth)

14495 A/CONF.15/P/895

Argonne National Lab., Lemont, Ill. and Purdue Univ. Lafayette, Ind.

EXPERIMENTAL CONSIDERATION OF THE GENETIC EFFECT OF LOW DOSES OF IRRADIATION ON VIABILITY IN DROSOPHILA MELANOGASTER. A. B. Burdick and T. Mukai. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

There is much evidence to indicate that the homozygous state of most irradiation induced mutations is deleterious with respect to viability. However, in random mating populations, the homozygous state of a deleterious mutation is not achieved very frequently unless the heterozygous state is associated with higher-than-normal viability. In addition, most of the deleterious alleles of a gene in a random mating population will exist in heterozygous condition, not in the homozygous condition. Therefore, in determining the genetic effect of irradiation on random mating populations, it is much more important to determine the heterozygous mutant effects since most of the population consequence will be manifest from this condition. Using the complete marked inversion (CMI) technique for the duplication of single genomes, we obtained two homozygous lines (W-126 and W-126-pol) which were genetically identical except for the fourth chromosome gene pol which was homozygous pol in one line and homozygous wild type in the other. We irradiated sperm in vivo from W-126-pol with 0, 75, 150, and 300 r of 1 mm aluminum filtered x rays, collected and discarded the mature sperm and proceeded to isolate in homozygous condition (by CMI technique, again) about 80 genomes per treatment from immature-when-irradiated sperm. This yielded about 320 homozygous lines differing from one another only to the extent of irradiation induced new mutations, and each marked with pol. Line W-126, untreated and unmarked by pol but identical with the pol-marked experimental lines except for new irradiation induced mutations, was used as a standard competitive test background in the viability studies which followed. We double-mated, in the same bottle and individually for each experimental line, W-126-pol males to pol-marked experimental females (to produce pol- progeny that were identically heterozygous for a single irradiation produced genome) and to W-126 females (to produce identically homozygous, pol-heterozygous progeny). The per cent of pol offspring in each of these test cultures was observed as a measure of viability of the irradiation treated genomes in heterozygous condition. The results indicated that the mean viability of all treated and control groups was about the same except for the 75r treated group where the mean viability was significantly higher than that of the control. We do not yet wish to attach any general significance to this higher mean viability of the 75r group. The most important and significant observation made was that the genetic variances of all of the irradiated groups were highly significantly greater than those of the control, the control versus treated variance comparison for the 75r group being 96 versus 265. Furthermore, the variance increase of experimental groups was homogeneous, that is, not marked by a few discreet viability differences, but by many small differences. These mutations are dominant in the sense that they produce a phenotypic effect in heterozygous condition. The large variance increases produced by these low doses of irradiation indicate that a great many more mutations were produced than would be expected from present estimates of the number of potentially mutable genes and their average mutation rate per roentgen unit. The mutations produced appear to be equally likely to increase or decrease viability when in heterozygous condition. These hitherto unsuspected results call for a reevaluation of our estimates of the genetic effect of low doses of irradiation in random mating populations. They mean that many more mutations, capable of expression in heterozy

gous condition, are produced than our previous estimates of gene number and mutation rate would indicate. They mean that the genetic material is far more sensitive to this type of dominant mutational event than has heretofore been thought, and that the curious nature of these mutations is that they are quite as likely to be viability-beneficial as detrimental. The results further indicate that the rate of increase in frequency of homozygously detrimental irradiation induced mutations may be much greater than previously expected since their likelihood of being either heterozygously beneficial or accompanied by dominant viability increasing mutations is much greater than formerly considered. (auth)

14496 A/CONF.15/P/896

Texas. Univ., Houston. M. D. Anderson Hospital and Tumor Inst.

INTERRELATIONS OF NUCLEIC ACID AND PROTEIN SYNTHESES IN RADIATION INDUCED MUTATION INDUCTION IN BACTERIA. F. L. Haas and C. O. Doudney. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

During the past decade evidence has accumulated that an appreciable portion of radiation-induced mutations are due to chemical effects of radiation on sensitive metabolites. The shape of induced mutation frequency curves suggests that intracellular radiation-sensitive material is modified by radiation. This material is probably both limited in quantity and destroyed by radiation since the mutation frequency reaches a plateau at high doses of radiation then usually decreases at still higher doses. We have found, using microorganisms, that the frequency of mutation per unit dose and maximum mutation frequency induced by ultraviolet (U.V.) may be increased considerably for various mutations. The same holds true when ionizing radiations are used, but increases in mutation frequency are smaller than with U.V. Increase is obtained by preirradiation incubation in minimal medium supplemented with yeast extract, a combination of purines and pyrimidines (adenine, or guanine, uracil, and cytosine) or their ribosides, riboflavin, or p-aminobenzoic acid. By using cultures synchronized in growth and division, the following has been established in regard to the purine-pyrimidine influence on U.V.-induced mutation: maximum frequency increase is attained by irradiating during maximum nucleic acid synthesis; little increase is observed following the first nuclear division; maximum frequency is reduced by cellular division; increased frequency obtained by purine-pyrimidine incubation bears no relation to cellular nucleic acid content-increase in nucleic acid precursors prior to irradiation is the important factor; increase in mutation frequency by purine-pyrimidine preirradiation incubation is dependent on postirradiation ribonucleic acid and protein syntheses. Postirradiation nitrogen-starvation, or inhibition of the RNA-protein synthesis system with chloramphenicol or 5-hydroxyuridine leads to rapid enzymatic decline in mutation frequency. The mutagenic effect of U.V. is modification of intracellular nucleic acid precursors. These modified precursors are stabilized by an amino-acid-dependent enzymatic process referred to as mutation stabilization. If stabilization is prevented they are rapidly removed by a second enzymatic process referred to as mutation frequency decline. Mutation is brought about by incorporation of the modified nucleic acid precursor(s) during macromolecular synthesis of RNA and protein, or mutation fixation. The nature of the link (if any) between modification of RNA and modification of the configuration of cellular DNA (the gene), though suggested by these results, is unknown. RNA and protein formation are involved in DNA synthesis, and perhaps changes in RNA biological specificity lead to corresponding changes in the biological specificity of genic DNA. (auth)

14497 A/CONF.15/P/897

Oak Ridge National Lab., Tenn.

RADIATION-INDUCED GENETIC DAMAGE IN MICE. W. L. Russell and Liane Brauch Russell. 15p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Large scale experiments were conducted using two different approaches to the problem of genetic radiation damage. The first of these is the specific locus method, by which the mutation rates at a sample of gene loci are measured accurately. The second approach is to measure the biological effects resulting from the total amount of mutation in descendant populations of irradiated animals. This method provides empirical measures of over-all damage that cannot be estimated accurately from information on a limited number of genes. The data from the specific locus experiments provide the first reliable estimates of mutation rates in mammals exposed to continuous, low level, gamma radiation. The results from experiments measuring genetic damage in populations extend the information recently presented on the shortening of life in the offspring of irradiated mice. These new results include additional data on lifespan and the first information on other vital statistics. In both approaches to the problem of genetic radiation damage, extensive data are, for the first time, being obtained for irradiated females as well as for males. The work on females, in addition to fitting into the experimental framework discussed above, has also provided basic information on chromosome aberrations, such as dominant lethals and translocations, and on radiation effects on female reproduction. The information gained from all experiments is integrated and applied to the estimation of genetic hazards of radiation in man. (auth)

14498 A/CONF.15/P/900

Pittsburgh. Univ. Graduate School of Public Health.

BRONCHOGENIC CARCINOMA FROM RADIOACTIVE PARTICULATES. Herman Cember. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Rats were exposed to radioactive dusts by inhalation and by intratracheal injection, to focal radiation sources by transpleural injection of small radioactive beads, and by external x irradiation to the lungs only. High incidences of bronchogenic carcinoma, as well as metaplastic changes that seemed to be premalignant in nature when observed in the context of the group experience, were observed in the cases of intratracheally injected $BaS^{35}O_4$, $Ce^{144}F_3$, and transpleurally injected Sr^{90}. Of particular interest is the short tumor induction times that were observed. In one case, a period of only 48 days elapsed between exposure to $Ce^{144}F_3$ and the observation of squamous cell carcinoma in the lungs. In all of these experiments, no bronchogenic carcinoma was observed in any control animals. Absorbed doses in rats that developed lung cancers ranged from 2,400 to 21,000 rad for the case of the intratracheally injected particulates. In one experiment in which no malignant changes were found, absorbed doses ranged up to 24,000 rep for intratracheally injected $BaSO_4$ particulates and up to 15,000 rep for external pulmonary irradiation.

The results to date clearly suggest that a continued radiological insult is a requisite condition for pulmonary carcinogenesis. (auth)

14499 A/CONF.15/P/902
Wayne State Univ., Detroit and Rochester, N. Y. Univ.
EFFECTS OF MATERNALLY ADMINISTERED P-32 ON FETAL DEVELOPMENT. M. R. Sikov, J. E. Lofstrom, and T. R. Noonan. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The effects of acute x-irradiation on prenatal mammals have been studied quite thoroughly. Much less attention has been paid to the effects on the conceptus of the more prolonged radiation from radioisotopes administered to the pregnant animals. We have sought to delineate these effects, to compare them with the effects of x-radiation, and to determine the reasons for the differences found. Pregnant female rats were injected after 6, 8, 9, 10, 14, or 17 days of gestation with graded doses of high specific activity Phosphorus-32 between 0.2 and 2.0 millicuries. The animals were sacrificed at intervals after injection ranging from 1/hour through birth. Certain of the embryos and fetuses were randomly selected for determination of the radioactivity content of the entire conceptus and of the individual organs when size permitted. Radiation doses in rep were calculated from the distribution data so that comparison could be made with published reports of x-ray effects. The remaining embryos were weighed and carefully examined for gross malformations and pathology. Histological slides were prepared from selected individuals from each litter for microscopic examination and stained skeletal preparations were made from the more advanced fetuses for study of skeletal development. For the earlier embryos, the toxicity of P-32 was determined in terms of the dose which, when administered to the mother, would be expected to kill 50% of the fetuses by the fourteenth day of gestation. These values, which were found to be dependent on the day of gestation on which injection was made were: day 6, 0.46 mc; day 8, 0.57 mc; day 9, 0.77 mc; and day 10, 1.29 mc. One millicurie or less did not increase prenatal mortality after administration on either 14 or 17 days of gestation. Two millicuries produced prenatal deaths when administered after 14 days of gestation but not after 17 days; some deaths attributable to the trauma of parturition were noted in both cases. Gross and histological examination disclosed many cases of anomalous development of the brain, eye, face, liver, kidney, and of other areas when injection was made in the 6 through 10 day period. After injection at 14 or 17 days of gestation, relatively little in the way of malformation was seen although many organs were found to be retarded in their development and were noted to be undergoing degenerative changes. Examination of the skeletons from these animals showed a reduction in skeletal size as well as alteration in the shape of some of the bones and relative dimensions of anatomic regions. Defects in the contour of the ribs and femur and other abnormalities were also noted. When the results of these experiments were compared with those found after acute x-irradiation, distinct qualitative and quantitative differences were found. A study of the differences indicated that no simple relationship exists between the effectiveness of the two radiations. We have found that dose rate, specific ionization, and similar variables do effect the response and that the direction and magnitude of the effect are related to the metabolic state of the specific tissue or organ at the time of irradiation. (auth)

14500 A/CONF.15/P/903
Minnesota. Univ., Minneapolis.
EFFECT OF X-RAYS ON THE CARDIOVASCULAR SYSTEM. W. O. Caster. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The effects of radiation on the cardiovascular system is reviewed. Studies involving localized x-irradiation of certain parts of the body of rats are reported in detail. The data from these experiments indicate that radio-induced heart damage results neither from direct irradiation of the heart nor from bacteremia but is associated with radiation damage in other parts of the body. (T.R.H.)

14501 A/CONF.15/P/906
Argonne National Lab., Lemont, Ill.
THE GENETIC FACTOR IN ACUTE AND CHRONIC RADIATION TOXICITY. Douglas Grahn. 12p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

For young adult mice exposed to single doses of whole-body x irradiation, the 30-day LD_{50} value varies with genotype from 500 r or less to nearly 700 r. Dosage-mortality slope data indicate that phenotypic variance of response is greater in sensitive strains than in resistant strains, in spite of equal levels of genetic homozygosity. The LD_{50} dose for first generation mice from crosses between radiosensitive and radioresistant strains shows hybrid vigor; however, this declines in subsequent generations. In contrast to the genetic non-additivity of the mid-lethal dose, the dosage-mortality slope, which is inversely proportional to the variance expresses additivity. The slope data indicate that from 55% to 60% of the observed variation in sensitivity in a heterogeneous population can be attributed to genetic factors. Among both inbred strains and their hybrids, a positive relation exists between normal life expectancy and LD_{50} dose, suggesting that the level of acute radiosensitivity reflects the general vitality of the individual. For example, mice with a low LD_{50} have poor normal survival, generally associated with high incidence of infectious disease mortality throughout life. Reduction of life expectancy for survivors for acutely lethal doses is a function of both sex and strain. Among males, percent reduction varies with strain from 16% to 29% as compared to 20% to 37% for females. Although LD_{50} and normal life expectancy are directly proportional, variation in reduction of life is not related to either parameter. In genetically different strains the same dose in roentgens will not produce a constant amount of chronic injury in terms of reduction of life. Genetic variation in mean survival time (MST) under duration-of-life exposure is also directly related to innate variation in normal life expectancy. This holds true for daily dose rates that yield MST values between 5 and 75% of the control. At low daily doses, this positive inter-strain relation becomes less distinct, and sensitive strains, with poor control expectations, appear to show smaller reduction of life than do more vigorous strains. However, the exact interactions between genotype, dose rate and environment, measured by changes in life expectancy, need further study. The results of these studies conform to a sufficiently definite pattern to permit certain generalizations. If a population group has, for either genetic or environmental reasons, a poor life expectancy, it will probably have a comparatively high sensitivity to acute radiation exposure. Proportional to this poor normal survival, survival

under continuous exposure will be short, except at very low dose levels where little change from normal may be observed. (auth)

14502 A/CONF.15/P/907
Argonne National Lab., Lemont, Ill.
PROTECTIVE COMPONENT IN NONIRRADIATED PROTOPLASM OF AMOEBAE. E. W. Daniels and H. H. Vogel, Jr. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Survival curves for the giant multinucleated amoeba, Pelomyxa illinoisensis, were obtained following exposure to x rays, γ rays, fission neutrons, and ultraviolet light. Individual supralethally irradiated amoebae were observed to recover after the direct addition by microfusion of protoplasm from nonirradiated cells. The nature of the protective component was investigated by studying the effects on survival and cell divisions of portions of nonirradiated cells that had been centrifuged at varying gravitational forces. The heavy and middle portions of such cells prevented death, but the light portions lost their capacity gradually as centrifugal force was increased. Surviving cells usually gave rise to mass cultures. At the present time it appears that the protective capacity resides in the fine particulate components or in the optically clear ground-plasm that suspends them. This conclusion is based on the finding that the beneficial effects of centripetal portions of nonirradiated cells are independent of the presence of nuclei and most mitochondria, while the progressive removal of the fine particulates is associated with decreasing ability of the cytoplasm to prevent death after fusion into lethally irradiated cells. (auth)

14503 A/CONF.15/P/908
Argonne National Lab., Lemont, Ill.
MODIFICATION OF SENSITIVITY TO RADIATION IN SINGLE CELLS BY PHYSICAL MEANS. E. L. Powers, R. B. Webb, and C. F. Ehret. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Information concerning the immediate interaction of ionizing radiations with biological material and the very early events following energy absorption is very scanty. Some knowledge of these phenomena exists for simpler chemical systems, but it is difficult to apply this knowledge biologically because of innate complexities of organisms. Furthermore, most biological systems cannot be manipulated with sufficient precision through the necessary range of physical variables to obtain reliable results. However, in recent years, a few studies have been aimed directly at the radiation sensitivity of microorganisms through a wide range of environments. These microorganisms include yeast cells, viruses, and spores of bacteria, especially the spores of Bacillus megaterium. Among the physical variables are water content, gaseous environment, temperature, and the various methods of changing dose patterns with changes in wavelength and dose rate. Studies which relate the results to those observed in simpler physical systems (e.g., crystals) are reviewed. Results in B. megaterium indicate that dose rate and temperature dependencies of radiation sensitivity are different from those reported for any other organism, and may be similar in some respect to results seen in purely chemical systems. (auth)

14504 A/CONF.15/P/909
Argonne National Lab., Lemont, Ill. and Chicago. Univ.
RESTORATION OF ANTIBODY-FORMING CAPACITY IN X-IRRADIATED RABBITS. W. H. Taliaferro and B. N. Jaroslow. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Normal rabbit or mouse spleen preparations restore hemolysin-forming capacity to 45% of its normal level in irradiated (400 r) rabbits, whereas similar normal rabbit kidney or muscle preparations are inactive. Restoration to the same degree is conferred by nucleic acid digests, ribonuclease, and a deoxyribonucleic acid derivative, kinetin. Neither the polymerized nucleic acids nor their purine bases and derivatives, i.e., adenine, adenosine, adenylic acid, or guanosine, were active. Yeast and HeLa cell preparations gave complete restoration. Yeast appears to contain kinetin or other nucleic acid products together with other factors which potentiate their activity. The restorative activity of these preparations may be associated with the nucleic acid control of protein synthesis. (auth)

14505 A/CONF.15/P/911
Argonne National Lab., Lemont, Ill.
THE INFLUENCE OF STRONTIUM-90 UPON LIFE SPAN AND NEOPLASMS OF MICE. Miriam P. Finkel, Birute O. Biskis, and Gertrude M. Scribner. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Predictions of the potential hazard to man of worldwide contamination with strontium-90 must be based largely upon the results of animal experimentation. Among the most useful criteria of radiation damage to the mammalian organism as a whole are decrease in life span and increase in the incidence of certain tumors. However, these effects can be studied and evaluated adequately only when large numbers of animals are observed for the duration of their natural lives. The mouse is admirably suited to this type of experimentation. Although the human problem is primarily one of deposition within the body of material that has been ingested or inhaled, extrapolations from mouse to man are simplified if the radiostrontium is given by intravenous injection because of species differences in absorption. At low levels the effective dose is probably that which becomes incorporated in the skeleton rather than that which passes through the gastrointestinal tract or lungs. Differences in uniformity of distribution, depending upon whether the period of exposure is relatively short or long, have been studied by administering the total dose in a single injection or in multiple, fractionated injections. The twelve dosages administered to 1320 CF No. 1 female mice ranged from acutely lethal levels to one that resulted in a body burden corresponding to approximately 10 μc/man, or to 10 times the present maximum permissible level for occupational exposure. The control population consisted of 240 mice. Neither the average life expectancy nor the time to 50% mortality plotted against the dose resulted in curves that could be described adequately by a simple linear function or by any of a number of mathematical transformations. At the three lowest levels the differences in survival between the experimental and the control populations were within the range of expected variation. A statistically significant difference in life expectancy was not seen below a dose roughly equivalent to 350 μc/man. The data on osteogenic sarcomas similarly failed to demonstrate a linear dose-response curve, and the number of such neoplasms among the 3 lowest dosage groups fell within the control range. Thus life span and malignant tumors of bone appeared to be equally sensitive indicators of radiation damage. Neo-

plastic change of the blood-forming tissues, however, proved to be a more sensitive criterion of injury. Although the incidence of reticular tumors was not markedly influenced by radiostrontium, they appeared earlier as the dose increased. The time required to reach a 20% incidence was significantly shorter among the animals that had received 8.9 μc/kg than it was among the control animals. This injected dose resulted in a body burden of approximately 1 μc/kg, which is roughly equivalent to 70 μc/man. Below this level the treated animals were indistinguishable from their controls. Since the differences in life span and neoplasms of bone and reticular tissues among the lowest doses and the control population were not statistically significant, it appears either that pathological change in the total mammalian organism is too crude a measure of toxicity at very low levels or that such levels actually are without effect. (auth)

14506 A/CONF.15/P/912
Brookhaven National Lab., Upton, N. Y.
RADIATION INDUCED AGING IN MICE. Howard J. Curtis and K. L. Gebhard. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experiments were undertaken in an effort to determine the degree of similarity between natural and radiation induced aging, and to determine the causes for the latter. Several severe non-specific stresses were applied to mice either as single massive doses or as smaller doses administered over a large fraction of the life span of the animals. Stresses used included typhoid vaccine, tetanus toxin, and tetanus toxoid and turpentine. None of these produced any premature aging comparable to that produced by radiation. The somatic mutation theory of aging and especially radiation-induced aging has been tested by applying the chemical mutagen, nitrogen mustard, either as a massive single dose or as smaller single doses repeated over long periods of time. No shortening of the life span has been observed and it is concluded that the somatic mutation theory is untenable. Experiments designed to determine the organ system responsible for radiation induced aging have demonstrated that the hematopoietic system is not primarily involved in this phenomenon. (auth)

14507 A/CONF.15/P/1784
Brown Univ., Providence.
IRRADIATION EFFECTS ON PIGMENT, HAIR FOLLICLES AND SKIN WITH RELATION TO COSMIC RAY HEAVY IONS, MICROBEAMS, AND THE OXYGEN INFLUENCE. H. B. Chase. 6p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Responses in the skin to irradiation depend on the skin cycle at the time of treatment, on the replaceability of cells, and on the homeostatic potentialities of certain cells. Responses also depend on physical factors such as the size of beam, oxygen tension in the tissues and probably LET and dose-rate. Ground-level studies with neon nuclei from the Heavy Ion Linear Accelerator will make possible a better comparison between thindowns of cosmic ray heavy nuclei and x-ray and electron millibeams, and will make possible a study of the oxygen effect relative to high ion densities. (auth)

14508 A/CONF.15/P/1844
California. Univ., Berkeley. Donner Lab.
THE ACTION OF PENETRATING RADIATIONS ON YEAST CELLS. Cornelius A. Tobias, Robert K. Mortimer, Ralph L. Gunther, and Graeme P. Welch. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Studies of survival of haploid and diploid yeast cells after single exposure to various penetrating radiations and particles led to the recognition of recessive and dominant lethal damage as operative in radiation-caused inhibition of cell division and to the migration model of radiation effects. A single penetrating charged particle (electron, proton, alpha particle, or carbon ion) is capable of producing both types of injury, leading to death in haploid cells and to death or impaired cell division in diploids. However, the biological site of damage is frequently not the actual site of primary ionization or excitation, but appears to be located at various distances from the track. Migration of the energy appears to be due to diffusion of chemical intermediates or to intramolecular migration of excitation energy. Heavily ionizing particles appear to be capable of producing greater injury farther from the ionizing tracks. In haploid cells lethal damage appears to occur so quickly that so far no postirradiation modifying factors have been demonstrated. In diploid cells, postirradiation factors do influence survival. Sublethal doses of radiation modify these cells for several generations and cause several demonstrable forms of effects. Among these are mutations, reduction of growth and cell-division rate, respiratory deficiencies, production of noviable progeny, increased sensitivity to re-irradiation, and recovery. Whereas progeny of a single irradiated cell are usually impaired in their growth rate and metabolic efficiency, the mutationlike recovery process results in rapidly dividing cells again. This entire phenomenon resembles the time development of radiation-induced carciongenesis in animals, and the underlying factors in the irradiated somatic cells of diploid animal tissue may be very similar. A number of experiments were carried out studying the effect of continuous x-irradiation on a population of yeast cells in steady-state proliferation in a chemostat. As much as 3000 r delivered in a generation time was well tolerated by the population, which is a few generation times, reached another steady-state, characterized by an increased period required for cell division. (auth)

14509 A/CONF.15/P/2172
Brookhaven National Lab., Upton, New York.
SOME FACTORS INFLUENCING RADIORESISTANCE AND TUMOR INDUCTION IN PLANTS. Arnold H. Sparrow and Lloyd A. Schairer. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A comprehensive review is presented of the effects of acute and chronic irradiation on plants. Major emphasis is placed on the cytological, histological, morphological, and developmental responses of plants to ionizing radiation. The tolerance of plants to ionizing radiation varies over a wide range. Original data and a summary of some published information concerning tolerance to both acute and chronic exposure will be presented. Various correlations between known characteristics and plant tolerances can be made. For instance, chromosome size and chromosome number are both of great importance in determining the tolerance of a given species. In addition to the inherent factors controlling radiosensitivity many environmental treatments can alter the response of plants to radiation treatment. The importance of these factors, whether laboratory controlled or a part of a natural environment, are considered. The possible significance of radioactive fall-out in relation to plant growth and the nature and extent of its uptake by plants will be mentioned. Practical uses

of radiation other than in plant breeding are so far rather restricted. Many reports of stimulation of plant growth have appeared but not all are reproducible. Recently a dramatic case has been reported for peach seedlings. Such findings may offer important clues to factors controlling growth and dormancy in plants. (auth)

14510 A/CONF.15/P/2324

Rochester, N. Y. Univ. School of Medicine and Denistry.

OBSERVATIONS ON RECOVERY AND IRREVERSIBLE RADIATION INJURY IN MAMMALS. John B. Hursh, George W. Casarett, Arland L. Carsten, Thomas R. Noonan, Sol M. Michaelson, Joe W. Howland, and Henry A. Blair. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

This presentation seeks to relate in time and magnitude the biological events that are inferred from paired dose lethality studies on experimental animals and the histopathologic observations following a single large x-ray exposure. The paired dose studies lead to the assumption that recovery from susceptibility to the lethal consequences of the second dose occurs in general at a rate such that within from a few days to a few weeks half-recovery is attained. The question is asked whether this recovery can be represented as a single exponential function. Results obtained with partial body irradiation of rats suggests that different tissues repair at different rates and that departures from the exponential relationship at very short testing intervals as found in selected data from the literature may perhaps be tentatively assigned to this cause. Other reasons are cited for doubting that recovery at all times may be precisely described as a single exponential process. The existence of an irreparable injury component is based on the life span shortening found for animal survivors of a large single dose. The amount of life shortening per roentgen depends on dose size. Less established is the proposition that the irreparable damage is constant throughout life and can be measured at all times by the reduction in the magnitude of a second dose necessary to produce an acute lethal result. Histopathologic radiation effects, reversible and irreversible, the temporal phases in the sequence of effects, and the tissue repair phenomena are related to phases of injury measured by paired-dose techniques or life span and are found compatible with certain hypotheses based on such measurements. Irradiated animals dying acutely or subacutely die largely of reparable but inadequately repaired injuries. Those dying later but prematurely die largely of diseases of the species advanced in onset as a result of advanced aging processes. The progressive arteriolocapillary fibrosis of aging, advanced by initial radiation injury of small blood vessels and fibrotic repair processes, precedes in development and later accompanies parenchymal senescence, which seems to be secondary to vascular senescence. (auth)

14511 A/CONF.15/P/2374

Argonne National Lab., Lemont, Ill.

FINE STRUCTURE OF CHROMOSOMES IN MAN AND OTHER METAZOA AND TESTICULAR RECOVERY FROM X-RAYS IN MAMMALS. B. R. Nebel. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Testicular recovery from acute localized exposure to 1000 r x radiation was studied in mice. Material from all sacrifices was subjected to light microscopy, electron microscopy, and autoradiography using tritiated thymidine. Observations are included on the contents of about 30 young spermatozoa observed with the aid of the electron microscope. (C.H.)

14512 A/CONF.15/P/2382

General Electric Co., Hanford Atomic Products Operation, Richland, Wash.

EVALUATION OF INTERNAL EXPOSURE HAZARDS FOR SEVERAL RADIOISOTOPES ENCOUNTERED IN REACTOR OPERATIONS. R. C. Thompson, W. J. Bair, S. Marks, and M. F. Sullivan. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Selected aspects of the hazards from radioisotopes encountered in the operation of a plutonium production plant are discussed. The material is derived in part from the actual experiences of plant operation, but more importantly from laboratory experiments designed to evaluate potential hazards. Absorption of plutonium from the gastrointestinal tract, while very low under conditions which would normally pertain to a contaminated water supply (absorption fraction = 3×10^{-5}), may be increased by nearly 100-fold in the very young animal, and may be much higher for acid solutions, or solutions containing complexing agents such as citrate. A single figure for fraction absorbed cannot therefore be expected to cover the variety of exposure hazards which may be encountered in a research laboratory or an industrial plant. To obtain information on the relative toxicity of different types of radiation exposure of the gastrointestinal tract, experiments were performed with rats comparing the acutely toxic effects of ingested, poorly absorbed alpha-emitters (Pu^{239}) and beta-emitters (Y^{91}) with the effects of x radiation applied to the exteriorized intestine, and to the intestine in situ. Effects of irradiation by ingested Y^{91} were qualitatively similar to the effects of x irradiation. Quantitative differences, such as greater relative damage to the large bowel, enhanced hematologic effects, and prolonged survival time, following Y^{91} ingestion as compared with x irradiation may be accounted for in terms of the altered distribution of dosage occasioned by the rate of passage of Y^{91} through the gastrointestinal tract. In contrast to these results with Y^{91}, ingestion of the alpha-emitting Pu^{239} in amounts as large as 200 mc/kg resulted in no acutely toxic effects attributable to radiation. For all practical purposes of hazard evaluation, alpha-emitting radioisotopes contained within the gastrointestinal tract may be ignored in calculating maximum permissible concentrations. Inhalation of radioisotopes in an insoluble, particulate form will, under most conditions of industrial exposure, constitute the most probable source of human contamination. Results are presented from experiments with mice and dogs which correlate the deposition, distribution, and excretion of PuO_2 and RuO_2 under various conditions of pulmonary exposure. Pathologic changes in mice included the production of malignant tumors following a latent period of at least 200 days. As little as 0.003 μc $Pu^{239}O_2$ deposited in the lung was found to be carcinogenic. Much higher levels of $Ru^{106}O_2$ were required to elicit similar effects. Results of investigations on the therapeutic removal of plutonium deposited in the lung or in bone, have been, in general, disappointing. The most effective of a wide variety of therapeutic agents tested was diethylenetriaminepentaacetic acid. Histopathologic and carcinogenic effects in the thyroid gland of sheep, resulting from single doses or pro-

longed daily administration of I^{131}, are discussed. The lowest daily feeding level causing consistent histologic damage was 5.0 μc/day. Tumors were observed in six of seven animals at this feeding level, at a minimum age of 53 months. The radiation dose to the thyroid glands of these animals was estimated to be about 30,000 rads. (auth)

Radiation Hazards and Protection

Refer also to abstract 15041.

14513 A/CONF.15/P/388
Massachusetts Inst. of Tech., Cambridge.
RETENTION OF FISSION PRODUCTS IN CERAMIC GLAZE-TYPE FUSIONS. M. I. Goldman, J. A. Servizi, P. S. Daniels, T. H. Y. Tebbutt, R. T. Burns, and R. A. Lauderdale. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Archaeological evidence has indicated the stability of ceramic glazes. Results are presented of investigations directed toward the fixation of fission products from high-aluminum-content fuel reprocessing wastes in a highly stable fused ceramic from which the fission products cannot be leached by water. Cesium is the most readily leached of the non-volatile fission products and was used as the test element for evaluation of composition parameters in the ceramic glaze systems: $CaO:Na_2O:Al_2O_3:SiO_2:B_2O_3$ and $CaO:Al_2O_3:SiO_2:B_2O_3$. The process advantage lies in the fact that aluminum (normally an interfering ion in many proposed waste treatment processes) is a necessary constituent of the solid product formed. The ceramic glaze can, in fact, be produced from the calcined product formed in the fluidized bed process employed at the Idaho Chemical Processing Plant. It is well known that fission products are easily leached from the latter. A new leaching test, which involves refluxing the product in distilled water, has been developed and adopted as a more sensitive indication of the retention of fission products in the ceramic. Volatility of fission products has been determined as a function of ceramic composition parameters and firing conditions with the objective of minimizing their evolution during the firing process. Radiation stability of various ceramic products has been investigated. Estimates of heat production and heat transfer characteristics have been used to develop conceptual process and storage facility designs. Extension of this process to wastes from processing of zirconium and stainless steel clad and alloyed fuel elements is discussed. (auth)

14514 A/CONF.15/P/390
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
RADIATION BIOLOGY AS A SUPPORTING FUNCTION FOR ATOMIC ENERGY INSTALLATIONS. H. A. Kornberg. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The radiation biology research and control programs at the Hanford Atomic Products site is described. Included is a review of research projects that arose because of knowledge needed to assess the hazards of radioactive gases, particles, and liquid effluents from the operation of reactors and chemical plants. A description of control procedures, necessary to provide continuing assessments of the effectiveness of radiation hazard control procedures by means of surveying terrestrial and aquatic animals is presented. (auth)

14515 A/CONF.15/P/391
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
WIND PICKUP OF RADIOACTIVE PARTICLES FROM THE GROUND. John W. Healy and James J. Fuquay. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Equations useful in predicting the air concentrations downwind from a source of radioactive particles deposited on the surface of the ground are derived. The rate of pickup by the wind is taken as proportional to the square of the wind speed and the dilution downwind as calculated from Sutton's equations. A correction for fall-out is made based on the gravity settling of the particles and the atmospheric turbulence. Integration of the point source equation leads to equations describing the concentration downwind from a line source, an area source of infinite extent and an area source infinite in extent in the cross-wind direction and of limited extent up-wind. The expression for the infinite area source derived in this manner is shown to be functionally similar to the one given by Bagnold in the Stoke's law region. The surface pickup coefficient used in the equations was evaluated from measurements of concentrations downwind from point sources of fluorescent particles of seven microns MMD on various surfaces. The influence of the nature of the surface and the nature of the particulate material is discussed and uncertainties in the derivation are analyzed. Some applications to the estimation of hazards resulting from the wind movement of radioactive particles are included. (auth)

14516 A/CONF. 15/P/393
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
RADIOACTIVE MATERIALS IN AQUATIC AND TERRESTRIAL ORGANISMS EXPOSED TO REACTOR EFFLUENT WATER. J. J. Davis, R. W. Perkins, R. F. Palmer, W. C. Hanson, and J. F. Cline. 13p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Coolant water which is discharged into the Columbia River from the Hanford nuclear reactors contain small amounts of many different radioisotopes. Recently developed instrumental techniques for the analyses of complex mixtures of radioisotopes were used to measure the radioisotopic composition of the river water and of organisms which utilized the river or which were maintained on high concentrations of direct effluent water. More than thirty radioisotopes have been identified and measured from Columbia River water. None were present in quantities near the limits for drinking water. All aquatic organisms which were common to the river downstream from the reactors were more radioactive than the water they inhabited. The kinds and amounts of radioactive materials which were concentrated differed among species of organisms. These differences were functions of several ecological and physiological factors. In general the plants, which are at the beginning of the food-chain contained the largest number of isotopes and organisms progressively farther up the series contained fewer. Fifteen different radioisotopes were measured from plankton collected near the reactors. Carnivorous fish for the same area contained significant quantities of P^{32}, Zn^{65}, and Cr^{51}

and traces of three to five other isotopes. The concentration of most isotopes in animals collected from the river were lower during the winter than during the summer because of differences in metabolic rates. Small amounts of P^{32}, Zn^{65}, and Cr^{51} were measured in some organisms which were collected at the mouth of the river which is over 360 miles below the reactors. The total concentration of radioactive materials in barley plants harvested from experimental plots irrigated with undiluted reactor effluent water was no more than twice that of barley irrigated with control water. Zn^{65} was the most concentrated gamma emitter in the plants. This correlated with the radioisotopic composition of terrestrial plants which were irrigated under natural conditions with water pumped from the river near the reactors. No effects from the radioactive material were observed, even plots irrigated for seven years were undiluted effluent. Eight radioisotopes were identified and measured in rats which were maintained for one year with concentrated reactor effluent water as their sole source of drinking water. Zn^{65} was the most abundant radioisotope measured in both bone and soft tissue. P^{32} was the second most abundant in both types of tissues. Despite the fact that the water drank contained concentrations of radioisotopes several thousand times higher than those which exist in the Columbia River immediately below the reactors, all radioisotopic concentrations measured were found to be only small fractions of the maximum permissible body concentrations recommended for humans by the International Commission on Radiological Protection. (auth)

14517 A/CONF.15/P/428
Convair, Fort Worth, Tex.
HAZARDS ASSOCIATED WITH FISSION PRODUCT RELEASE. B. P. Leonard, Jr. 25p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Current methods and assumptions used in predicting and extent of hazards from a reactor incident are described and analyzed. The effects of the choice of values of the important parameters are shown. Values for each are recommended to achieve realistic predictions while maintaining necessary conservatism. Particular attention is given to recent advances in predicting the release and dispersal of fission products. Experiments have shown that, in a reactor meltdown, only the volatile fission products will be released in significant quantities. Such a selective release is considerably less hazardous than a non-selective (vaporization) release because long life and bone seeking isotopes are retained in the reactor. (auth)

14518 A/CONF.15/P/430
Brookhaven National Lab., Upton, N. Y.
EXPOSURE CRITERIA FOR ESTIMATING THE CONSEQUENCES OF A CATASTROPHE IN A NUCLEAR PLANT. J. B. H. Kuper and F. P. Cowan. 12p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Estimates were made of the injuries to be expected as a result of exposure to a fission product cloud, and of the effects of ground contamination. A hypothetical 500 Mw (thermal) reactor was assumed to have been operating for six months. Two types of accident were postulated, one in which a large fraction of the total fission product inventory was released, and the other involving the escape of the volatile fission products only. Whole body exposures to beta and gamma rays, lung exposure to beta rays, and the exposures of body organs to deposited isotopes as a result of direct exposure to the fission product cloud were estimated. An attempt was made to reduce these to equivalent values of whole body exposure, to combine them, and thereby to obtain an over-all index of biological damage. It was concluded that for the full fission product release an exposure to more than 400 curie seconds per cubic meter (as measured at 24 hours after the accident) would likely be fatal, between 90 and 400 C-sec/m^3 illness would be unlikely but there might well be expenses involved in establishing absence of damage, and below 10 C-sec/m^3 no illness or expense would be anticipated. For the volatile fission product release the corresponding numbers are 350, 80 to 350, 10 to 80, and 10 C-sec/m^3. Estimates of the effects of contamination on land use are necessarily rather crude, and actions taken would undoubtedly depend on the size and character of the area affected. Again various components of external and internal exposure were considered. They were combined and criteria for evacuation and limitations on the use of land were proposed. It was concluded that for the full fission product release areas contaminated with more than 10^{-2} curies (measured at 24 hours) per square meter would have to be evacuated, that between 10^{-3} and 10^{-2} C/m^2 severe restrictions on land use and outdoor work would be required, between 10^{-4} and 10^{-3} some crops might have to be destroyed and temporary restrictions on agriculture would be expected, and that below 10^{-4} no restrictions would be necessary. For the volatile fission product release these figures would all be a factor of 10 greater. (auth)

14519 A/CONF.15/P/738
Rochester, N. Y. Univ. School of Medicine and Dentistry.
AN EVALUATION OF INHALATION HAZARDS IN THE NUCLEAR ENERGY INDUSTRY. J. N. Stannard. 15p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Factors to be considered in evaluating inhalation hazards in the nuclear energy industry are reviewed. A survey of results from recent studies indicates that power reactors present potentially a much greater inhalation hazard than weapons fall-out. It is concluded that it is unsafe to extrapolate from aerosol data pertinent to chemically toxic materials to radioactive aerosols. The hazard may be related more to numbers of particles than to the mass of material. Submicroscopic particles may be the most hazardous because of their numbers. While the gastrointestinal tract may at times contain more material than other organs, it is questionable if it should be considered the most critical organ. The accumulation of material in pulmonary lymph nodes, particularly after prolonged inhalation exposure, may greatly exceed that in lung. Lymph node accumulation may limit exposure under many conditions, and calculation of maximum permissible doses on this basis may be required. The lung is considered as a moderately radiosensitive organ with clearly measurable damage resulting from exposure to 1000 and 2000 r. Induction of invasive cancer by radioactive materials deposited in lung has been demonstrated, and the order of damage can be estimated. In normal operations, the mining and processing of uranium ore may involve the largest number of individuals and be the most likely source of radioactive inhalation hazard in nuclear energy work. Ventilation of mines and mills and the use of respiratory protective equipment can aid greatly in relieving this hazard. (C.H.)

14520 A/CONF.15/P/739

Rochester, N. Y. Univ. School of Medicine and Dentistry.

THE QUESTIONS OF HEALTH HAZARDS FROM THE INHALATION OF INSOLUBLE URANIUM AND THORIUM OXIDES. Harold C. Hodge and Robert G. Thomas. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The insoluble compounds of uranium and thorium, particularly the oxides, are important in the development of atomic energy. The questions of health hazards from exposures to dusts of these insoluble compounds are strikingly similar in many but not all respects. Among the similarities may be listed the following facts: The insoluble compounds present no chemical hazard. Both uranium and thorium dioxides, for example, are remarkably inert physiologically. No radiation injuries have so far been described in the lungs of experimental animals inhaling dust concentrations many times the recommended MAC. The lungs of a few dogs studied seven years after excessive inhalation exposures to ThO_2 gave negative histological findings although high concentrations of thorium were present. The MACs for insoluble uranium and for insoluble thorium dusts are identical, specifically 3×10^{-11} c/l. Calculated on a radiation basis, a lower MAC is appropriate for thorium. Based on a considerable body of information from animal studies and a steadily growing record of human exposures, indices of lung burden can be selected. For both uranium and thorium dioxides fecal excretion reflects the immediate exposure to dusty atmospheres. Urine analyses are a prime index of uranium exposure whereas the presence of the much less soluble thorium dioxide in the lung cannot be thus assessed. Breath thoron estimations or possibly measurements using a whole body counter have been recommended as indices of thorium exposure. The fundamental question depends on the radiosensitivity of the lung and of the pulmonary lymph nodes; neither the production of radiation injury nor the production of cancer are evaluated at present with respect to dosage of radiation. The lung tissues of the dogs described above must have received several thousand rem during the 7 year period. The pulmonary lymph nodes must have received considerably more radiation because the concentrations in these nodes were 20 to 40 times those of the lungs. The wide use of the insoluble oxides and the low MACs combine to raise recurring questions of health hazards. (auth)

14521 A/CONF.15/P/740

New York Operations Office. Health and Safety Lab., AEC.

EXTERNAL ENVIRONMENTAL RADIATION MEASUREMENTS IN THE UNITED STATES. L. R. Solon, W. M. Lowder, A. V. Zila, H. D. LeVine, H. Blatz, and M. Eisenbud. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Conference Version of HASL-25.

During the Summer of 1957, measurements were made of the external environmental radiation in numerous locations throughout the United States. Measurements were made with an ionization chamber inside an automobile under essentially identical field conditions of car loading and ionization chamber orientation, it having been established previously that the car attenuation did not affect the measured values in an important way (about 5 percent). The purpose of these measurements was to establish the approximate range of population exposures to the penetrating environmental radiation component, cosmic radiation and terrestrial gamma radiation, but excluding terrestrial beta radiation. (auth)

14522 A/CONF.15/P/741

General Electric Co., Schenectady, N. Y.

RADIATION PROTECTION IN THE INDUSTRIAL USE OF RADIATION. W. A. McAdams. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

During the last few years the use of radiation and radioactive materials by American industry has begun to play a vital role in the development and improvement of commercial products and in the simplification and control of manufacturing processes. This is evidenced by the increase in AEC licenses for the use of reactor by-product materials, and also by the increase in the industrial use of x-ray equipment, particle accelerators, and radioactive materials not under AEC control. This increase in radiation work can have a serious effect on the health and safety of both the workers and the general public, if proper radiation practices are not observed. To illustrate how industry has learned to deal effectively with the hazards of radiation, both on a large and small scale, the radiation protection programs of the General Electric Company are described. General Electric has had a long experience in radiation and atomic energy fields and more than 70 of its departments are now engaged in radiation work of one kind or another. Since the Company is a highly diversified and decentralized organization, the radiation protection programs of the various branches are quite varied. Although the majority of radiation workers in General Electric are employed at AEC facilities, this paper gives most of its attention to other radiation work, including the manufacture of x-ray equipment; the production of electron tubes, starter switches, luminescent timepieces and other products containing radioactive materials; radiographic testing; activation analyses; production gaging and control; and radiation studies on the physical and chemical properties of materials. Radiation exposure records are summarized, monitoring and control procedures are described, and unique protection problems are analyzed. Special design techniques used for the protection of customers and the general public are also discussed. One section of the report deals with the radiation hazards of manufactured equipment, such as projection TV apparatus, and high power electronic devices. (auth)

14523 A/CONF.15/P/743

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

RADIATION EXPOSURE TO PEOPLE IN THE ENVIRONS OF A MAJOR PRODUCTION ATOMIC ENERGY PLANT. J. W. Healy, B. V. Andersen, H. V. Clukey, and J. K. Soldat. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The permissible dispersal of radioactive wastes from an atomic energy plant is limited by the radiation exposures which may occur to individuals or populations living in the vicinity. This exposure is dependent upon the type of plant, and therefore the form and quantities of wastes discharged, and upon the ecological nature of the plant environs. A review of information available on sources of environmental exposure to humans from one major complex consisting of both reactors and separations plants is made to indicate levels of radiation exposures involved. For single-pass, water-cooled reactors, the effluent water containing both neutron activation products and traces of fission products con-

stitutes the major source of waste release. Dispersal of this water in a major river reduces the concentrations in the plant environs but ecological mechanisms provide concentration factors in plants and animals. The high level liquid wastes from the separations areas are stored in underground tanks while the lower level liquid wastes are dispersed to the soils of the region where they are retained above the water table. As a result, the only separations plant wastes reaching a point of public use are the small quantities of fission products contained in the ventilation air and process gases released through stacks after pre-treatment. The concentrations of various isotopes resulting in air, water, and foodstuffs in the vicinity of the plant are reviewed to indicate levels attained. Methods of assessing the overall radiation exposure from these concentrations are indicated. The total exposure is estimated and compared with natural background, contributions from fallout, and national limits. (auth)

14524 A/CONF.15/P/751

National Bureau of Standards, Washington, D. C.

THE INFLUENCE OF LOWERED PERMISSIBLE DOSE LEVELS ON ATOMIC ENERGY OPERATIONS IN THE UNITED STATES. Lauriston S. Taylor. 9p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

It would appear that the introduction of lowered maximum permissible dosage levels and the age-proration principle for distributing the dose, should not introduce any insurmountable problems in the United States. A greater premium will be placed upon operating under minimal exposure conditions and the utilization of adequate monitoring and records systems. Radiation control outside of controlled areas will present some greater difficulties in a few instances, but even these difficulties do not appear to be too severe. Because radiation control practices in the United States have been conservative in the past, it is anticipated that little change will be required in operations or operational procedures upon the introduction of the lowered permissible dose levels and the age-proration principle. (auth)

14525 A/CONF.15/P/757

Oak Ridge National Lab., Tenn. and Tennessee. Univ., Knoxville.

A SUMMARY OF DATA THAT WAS USED IN THE REVISION OF THE INTERNAL DOSE RECOMMENDATIONS OF THE INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. K. Z. Morgan, I. H. Tipton, and M. J. Cook. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The report of the Internal Dose Committee of the International Commission on Radiological Protection has been revised and released for publication. The basic principles and fundamental philosophy of radiation protection are unchanged in this new publication, but a number of revisions are made. The most important of these is the reduction of maximum permissible concentration, MPC, of radionuclides in air, water, and food so that the average RBE dose rate to the total body of the occupational worker will be one-third of that formerly permitted. This reduction is intended to reduce the probability of chronic damage, e.g., leukemia and premature aging. The MPC values for bone-seeking radionuclides continue to be based on an accumulation in the bone that is estimated to deliver a RBE dose rate equal to that received from 0.1 μg of Ra^{226} and its daughter products. These values were reduced by 32% because recent data indicate that only 30% (rather than 55%) of the daughter products of Ra^{226} is retained in the body. The new MPC values correspond to a RBE dose rate of 0.56 rem per week to the bone, 0.6 rem per week to the thyroid or skin, 0.1 rem per week to the total body or gonads, and 0.3 rem per week to all other organs of the body. A major objective in the revision of the ICRP Handbook has been to obtain reliable values for the distribution of radioelements in the human body following many years of exposure. One of the best sources of such data is the normal distribution of stable isotopes of these elements in the human body. For the past six years a study of human tissue has been conducted by the Oak Ridge National Laboratory in cooperation with The University of Tennessee. This study includes a spectrographic analysis for 37 elements in 35 body organs, from over 300 autopsies that were supplied from 15 countries. For elements such as Ca, Fe, Zn, Cu, Mn, etc., which are known to have a role in the body economy, the geographical variation is not large—reflecting the state of nutrition of the population. For other elements such as Sr, Cd, Pb, Al, and Cr which may compete with necessary elements in their normal roles, the geographical variation is striking. Some elements such as Cu and Zn in liver, Al in lung, and Cd in kidney, show marked variation with age of subject. Such data are useful not only in calculating the MPC values for the standard man but may serve also as a guide in making refinements to the MPC values when applying them to individuals of a given age, weight, eating habits, etc. MPC values are given for 86 radionuclides in the 1955 ICRP Handbook and for 227 radionuclides in the 1958 edition. Also, MPC values are given for insoluble as well as soluble radioactive materials and for several critical body organs resulting in a seven-fold increase in the number of MPC values. In a few cases (where sufficient data are available) the MPC values are based on a power function rather than an exponential function of the time of exposure. (auth)

14526 A/CONF.15/P/758

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

RADIATION PROTECTION RECORDS AT A MAJOR ATOMIC ENERGY FACILITY. A. R. Keene, J. W. Vanderbeek, and E. C. Watson. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A system is described whereby the radiological exposure status of some 9,000 individuals and their environment is determined, evaluated, and recorded. The facility involved has a full spectrum of atomic energy activities. Included are the fabrication of radioactive fuel elements, the utilizing of these fuel elements in several water cooled reactors, the processing of the fuel after irradiation, plus the many supporting activities such as radiation laboratories, Van de Graaff generators, x ray machines, and waste disposal. The radiological controls and records of these work locations, (particularly the Radiation Zones) is detailed. (auth)

14527 A/CONF.15/P/887

California. Univ., Berkeley. Crocker Lab. and California. Univ., Berkeley. Donner Lab.

ESTIMATION OF THE TURNOVER EQUATION OF STRONTIUM-90 FOR HUMAN BONES. Patricia Durbin and Hardin Jones. 4p. (UCRL-8083). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experiments are reported in which the turnover equa-

tions for Ca^{45} and Sr^{90} in adult rats and for Sr^{90} in monkeys were obtained. Similarities between Sr^{90} turnover equations for rat and monkey suggest that the turnover equation for the monkey may approximate that of the human skeleton. (T.R.H.)

14528 A/CONF.15/P/889
National Cancer Inst., Bethesda, Md.
INDUCED RECOVERY OF BLOOD-FORMING TISSUE IN IRRADIATED ANIMALS. Willie W. Smith. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Survival of lethally irradiated mice and hamsters is enhanced by a single injection of a bacterial endotoxin given from 24 hours before to several hours after exposure. This is invariably associated with an advance in hemopoietic recovery but is not necessarily associated with the increase in resistance to bacterial challenge conferred upon normal mice by one or more injections, or with the granulocytosis commonly seen within 24 hours after an endotoxin injection. Colchicine and several of its derivatives increase survival in mice when given a day or two prior to irradiation. The protective effect abruptly ceases at exposures which kill untreated mice in 8 days or less. This protection also is associated with an advance in the time of hemopoietic recovery. We have thus far seen no protection in animals given colchicine after irradiation. (auth)

14529 A/CONF.15/P/894
Argonne Cancer Research Hospital, Chicago and Chicago. Univ.
ANTIBODY FORMATION IN X-IRRADIATED RATS PROTECTED WITH RAT OR RABBIT HEMATOPOIETIC CELLS. Mariano F. LaVia, Eric L. Simmons, and Joanne D. Denko. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Rats receiving lethal amounts of total-body x radiation were injected with liver cells from rat and rabbit embryos. Two to 7 weeks after this treatment, groups of animals were intravenously given a mixture of bovine serum albumin and Salmonella typhi vaccine. Sera were obtained 1 week after antigen injections. Titers were carried out to detect anti-typhoid and anti-BSA antibodies. Rabbit-treated rats had positive titer to BSA. They exhibited a delayed recovery of antibody-forming capacity to both of the antigens that were administered. Although rat-treated rats recovered their antibody-forming capacity earlier, they did not show any response to BSA. These results confirm the observations that heterologous cells administered after total-body x irradiation can survive and function for long periods of time. (auth)

14530 A/CONF.15/P/898
Oak Ridge National Lab., Tenn.
NEW DEVELOPMENTS IN RADIATION PROTECTION AND RECOVERY. Alexander Hollaender, C. C. Congdon, D. G. Doherty, T. Makinodan, and A. C. Upton. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An important new finding in protection and recovery at the cellular level is the enhancement of rejoining of chromosome breaks by supplying energy within a short time after exposure to radiation. This indicates the feasibility of reducing radiation injury by appropriate treatments shortly after irradiation. The protective effect of certain chemical agents varies widely among different species and strains of microorganisms. In some cells, protective compounds actually increase the yield of radiation-induced mutations. The mechanism and significance of this effect remain to be determined. Studies on the distribution of AET and related compounds in different tissues and in various fractions of the cell support the hypothesis that these agents protect against radiation by quenching free radicals. Experiments with transplantation of bone marrow and spleen cells show that survival may be enhanced by the reconstitution of damaged tissue through cellular replacement. From these studies a wealth of information about transplantation immunity and the passive transfer of antibody-forming systems has been derived. Determination of the chemical nature of the antigens responsible for heterograft (bone marrow) rejection should provide the immunologist with new ways of studying tissue transplantation. Life-span observations of irradiated mice protected with AET and bone marrow indicate the effectiveness of these agents in reducing the severity of delayed effects of radiation. (auth)

14531 A/CONF.15/P/1060
Rockefeller Foundation, New York.
FREQUENCY OF BONE SARCOMA IN THE UNITED STATES IN RELATION TO LOW LEVEL RADIATION EXPOSURE. John C. Bugher and Pauline A. Mead. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Between areas of the United States differing in natural background radioactivity by a factor of two, there is no corresponding relationship in the incidence of deaths from malignant tumor of bone as observed over the period 1949-1955. No evidence is found in this study which supports the assumption of linear relationship of bone tumor incidence and ionizing radiation at low doses. If a threshold exists for causation of bone tumors, it must lie well above 20 rads and probably nearer 1000 rads. The mortality experience from malignant tumors of bone in the United States can be described in terms of two populations, each exhibiting a Gompertz type of mortality. One of these populations is a small one behaving as though all of the individuals were destined at birth to die of bone sarcoma at an early age. (auth)

14532 A/CONF.15/P/1431
California Research Corp., Richmond, Calif.
TEN YEARS' SAFE USE OF ISOTOPES IN PETROLEUM LABORATORIES AND REFINERIES. B. A. Fries and D. E. Hull. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Most of the radiation problems in using isotopes in petroleum refineries and research laboratories relate to external exposure. Any task that exposes a worker to more than 7 mr/hr calls for radiation protection. Safety equipment and procedures are designed to take maximum advantage of the factors of distance, time, and shielding, in that order. This results in exposure 10 to 100 times below tolerance without costly remote handling tools and massive shielding. These principles are illustrated by their application to actual problems. (auth)

14533 A/CONF.15/P/1542
Rochester, N. Y. Univ. School of Medicine and Dentistry.
TRAINING PROGRAMS AND CHALLENGES IN NUCLEAR ENERGY AND THE LIFE SCIENCES. J. N. Stannard. 5p. $0.50(OTS).

Prepared for the Second U. N. International Con-

ference on the Peaceful Uses of Atomic Energy, 1958.

The field of health physics is defined, and opportunities, training programs, and future needs are discussed. (W.D.M.)

14534 A/CONF.15/P/1773

Robert A. Taft Sanitary Engineering Center, Cincinnati.
BENEFICIAL APPLICATIONS OF RADIATION IN SANITARY ENGINEERING. D. A. Pecsok, H. P. Kramer, and D. W. Moeller. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Essentially every phase of sanitary engineering has benefited from the products of nuclear technology. Because the potentialities of these applications appear to be endless, it can be anticipated that they will enjoy continued growth in the future. The goal of sanitary engineering is the improvement of the public health, principally through the control of man's environment. Nuclear science and technology are assisting in the attainment of this goal. (auth)

14535 A/CONF.15/P/1796

Argonne National Lab., Lemont, Ill.
RECENT DEVELOPMENTS IN FACILITIES FOR HANDLING PENETRATING RADIATION. R. C. Goertz. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Facilities for performing experimental operations on materials emitting penetrating radiations show an increase in number, size, and shielding capacity. Many of these facilities are functionally similar to their predecessors; however, a few new facilities are being designed to carry out all of the operations by remote control. Personnel will enter only to handle unusual problems. These facilities may be tightly sealed to contain large amounts of highly toxic materials such as irradiated plutonium and, in some cases, will be provided with an inert atmosphere. A new mechanical master-slave manipulator is being designed to have a load capacity of 50 lbs, to incorporate gas seals and to have the master and slave arms easily removable for servicing. A new master-slave servo-manipulator having a load capacity of 30 lbs is well along in design. Glass for thick shielding windows can be improved for very high exposures by adding greater amounts of cerium oxide. (auth)

14536 A/CONF.15/P/1835

Johns Hopkins Univ., Baltimore. Chesapeake Bay Inst.
FACTORS AFFECTING THE DISPERSAL OF FISSION PRODUCTS IN ESTUARINE AND INSHORE ENVIRONMENTS. D. W. Pritchard. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

It is likely that increased use of nuclear power reactors on land, and nuclear powered naval and merchant marine vessels, will result in release, in the normal course of operation, of some low level waste products to the estuarine and inshore environment. Despite extreme care in design to limit the possibility of accidental release of large amounts of activity, there still remains that outside chance of an accident to a land based plant adjacent to an estuary, or to a nuclear powered vessel traversing the estuary. Fission products released to the estuarine environment will occur in the following forms: as dissolved material; as colloidal or finely divided suspensions; attached to the natural suspended sediment load; as part of the bottom sediments; or in the phytoplankton and in sessile filter feeders. That portion of the activity existing in solution, or as a colloidal or finely divided suspension, will be carried by the currents in the estuary and dispersed through processes of turbulent diffusion. In this paper the character of the circulation and mixing of estuarine waters, in relation to dispersal of waste material, is discussed. Many of the world's major harbors occur in coastal plain estuaries, where there occurs, superimposed on the more evident oscillatory tidal motion, a net circulation pattern with the upper layers exhibiting a net seaward motion and the lower layers exhibiting a net landward movement. Such water movements would be effective in dispersing the released fission products throughout the estuary. The manner in which other possible circulation patterns would affect the dispersal is discussed. The theory of the movement and diffusion of the water borne contaminant is presented. Various mathematical models of the phenomenon are described, and possible numerical solutions using high speed electronic computers are indicated. Hydraulic models can serve effectively in obtaining both immediately practical and basic information on the dispersal of contaminants in estuaries. Some results of studies in a model of the Delaware Estuary are presented. The computed time-spacial distribution of a contaminant, as obtained from the numerical solution of a simple mathematical model, is compared to the observed distributions in the hydraulic model. The manner in which the analysis must be ultimately modified to take into account the effects of the non-conservative processes of continued uptake of activity by the suspended sediment load and by the biota is also presented. Such modification must await results of basic laboratory studies on the interaction of the fission products with natural suspended sediments and with specific estuarine organisms. The processes of zeolithic exchange and adsorption interactions between the fission products and the natural suspended sediment in the estuary are discussed. The manner in which the circulation pattern affects the movement and final settlement of the silt to the bottom, together with the attached activity, is described. In the case of most estuaries, there is a preferred location of major sedimentation which is controlled primarily by the density induced circulation pattern. Radioactivity would be concentrated on the bottom in such regions of the estuary. (auth)

14537 A/CONF.15/P/2352

Michigan. Univ., Ann Arbor. Law School.
LEGAL PROBLEMS OF LIABILITY AND FINANCIAL PROTECTION CONNECTED WITH RADIATION INJURIES. E. Blythe Stason. 28p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Industrialists, prospective reactor operators, and all others engaged in the peaceful applications of atomic energy are increasingly interested in the scope of the legal liabilities and the means of protecting themselves against loss. Answers are presented to the most commonly asked questions in this field. (C.H.)

14538 A/CONF.15/P/2497

Idaho Operations Office. Health and Safety Div., AEC and Tennessee. Univ., Memphis. [Coll. of Medicine].
BIOLOGICAL MONITORING OF RECENT AIR-BORNE FISSION PRODUCTS. N. R. French and L. Van Middleworth. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Accurate monitoring data can be obtained by continuous observations of thyroidal I-131 in indigenous animals. Interpretations of the data in terms of the quantitative contamination of vegetation or atmosphere

requires calibration of the animals in their natural environment. Qualitative data regarding the levels of I-131 in animal populations are sensitive indices to changes in relative contamination. Complete interpretation of these data will require continuous monitoring of animal thyroids. Examples are given in which the method proved to be a sensitive and useful index of biological contamination. It is proposed that these methods could be used on a large scale as a routine monitoring procedure. (auth)

Radiography

14539 A/CONF.15/P/406

New York. State Univ. Coll. of Medicine, Brooklyn.

AUTORADIOGRAPHY IN BIOLOGY AND MEDICINE. P. J. Fitzgerald. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A survey of the autoradiographic technique and its applications is given. It is pointed out that cellular function may be studied by this method as a supplement to the organ concentration of standard counting techniques. The merits of intracellular and even intrachromosomal localization of tritium-labeled compounds in such studies are emphasized. (auth)

14540 A/CONF.15/P/822

Brookhaven National Lab., Upton, N. Y.

EUROPIUM-155 AS A SOURCE IN PORTABLE RADIOGRAPHIC DEVICES. James S. Robertson. 9p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The problem of obtaining radiographs suitable for diagnostic interpretations in locations remote from adequate power supplies leads one to look to the gamma-emitting radioisotopes as possible substitutes for x-ray machines. Energetic gamma emitters such as cobalt-60 have been used successfully in industrial radiography. In order to achieve the necessary contrast, however, in radiographic work with human beings, gamma rays of much lower energy are required. Europium-155 offers the following advantages: a half-life of 1.7 years; 100% of the disintegrations yield 85 or 99 kilovolt gamma rays; the β^- energy is only 0.25 Mev, and at least in principle it can be produced carrier-free Europium-155 is produced from samarium-154 by the $(n, \gamma\text{-}\beta)$ reaction. The production of europium-155 is relatively difficult because some of the other isotopes of samarium have very large neutron capture cross sections. Europium-155 itself also has a large neutron capture cross section, resulting in its burn-up in a reactor. The use of magnetically separated samarium-154 as the target material, a high neutron flux, and a short in-pile neutron activation time, however, makes the production of europium-155 feasible. The europium-155 can be separated from the samarium-154 by a column exchange method and the recovered samarium can be reused again and again, so that any desired quantity of europium-155 can be built up. Millicurie quantities of europium-155 have been produced in exploratory runs. Radiographs made with these sources are comparable in quality with those made with thulium-170 sources. These radiographs are suitable for much of the diagnostic work that has to be achieved under emergency field conditions, but is not as good as is achieved with the best x-ray techniques. It seems possible that the quality may be improved if special films are used. (auth)

14541 A/CONF.15/P/828

Picker X-Ray Corp. Picker Research Center, Cleveland and Michigan. Univ., Ann Arbor. Fission Products Lab.

STUDIES ON X-RAYS AND BREMSSTRAHLEN FROM SOURCE-TARGET MIXTURE. E. W. Coleman, L. E. Brownell, and C. J. Fox. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Homogeneous mixtures of beta-emitting radioisotopes with stable target materials were investigated as possible radiation sources for medical radiography. Mixtures containing Ca^{45}, Tl^{204}, or Pm^{147} as chemical compounds have been prepared and their spectra determined. Radiographic testing of these sources indicates that Pm^{147}, or other low-energy beta emitters, show promise for use as medical x-ray sources. (auth)

Radiotherapy

14542 A/CONF.15/P/872

Argonne Cancer Research Hospital, Chicago and Chicago. Univ.

ISOTOPES DECAYING BY ELECTRON CAPTURE: A NEW MODALITY IN BRACHYTHERAPY. Paul V. Harper, Katherine A. Lathrop, Louis Baldwin, Y. Oda, and L. Kryshtal. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The use of conventional interstitial radiation therapy at operation entails unavoidable exposure to the surgeon. A number of ways have been devised to circumvent this difficulty. Developments in reactor technology have made available new isotopes with properties particularly suitable for this type of application. Palladium-103, which decays with a half-life of 17 days, emits principally 20-kv x rays. This radiation is shielded completely by thin lead foil so that handling problems are negligible. The penetration of the soft x rays through tissue (half-value layer about 1 cm) is sufficient that a more or less even distribution of radiation in an implant may be achieved with sources spaced 1 cm apart. The relatively long half-life means that the dose rate is low, and the initial activity in the implant is reduced correspondingly. The isotope is prepared by the irradiation of palladium metal in a high flux reactor, chemical separation of the daughter silver-111, and precipitation of the palladium as palladium black, in which form it may be injected as a suspension in gelatin solution. The palladium black, which is a coarse precipitate, remains at the site of injection and produces very little reaction in the tissues, either in the inert or radioactive form. Results in the treatment of experimental tumors have been encouraging, and use of the isotope in the parametrium is planned in cases of advanced carcinoma of the cervix. (auth)

14543 A/CONF.15/P/874

Chicago. Univ. and Argonne Cancer Research Hospital, Chicago.

TRANS-SPHENOIDAL HYPOPHYSEAL DESTRUCTION WITH RADIOACTIVE YTTRIUM. Robert D. Moseley, Jr., William M. S. Ironside, and Paul V. Harper. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Utilizing simultaneous biplane fluoroscopic image intensifier control, small 1-mc Y^{90} pellets have been introduced into the hypophysis via the pre-nasal transsphenoidal route. Generally, eight pellets have been

used in a single plane implant with an anterior and posterior row of pellets 4mm apart and with each pellet in a row 4mm from the ones adjacent to it. This distribution produces a rather homogeneous interstitial beta radiation of 200,000 rads. Patients with neoplasma susceptible to hormonal modulation, notably metastatic breast and prostate carcinoma, have been treated by this method. The use of local anesthesia and the short duration of the operative procedure make the method available even to patients in advanced stages of disease. The early results of this form of therapy are presented. Complications of the procedure include a very small incidence of ocular nerve palsies and cerebrospinal rhinorrhea; these are reported in detail. There have been no deaths attributable to the operation. Previous related work, the preparation of the yttrium pellets, the operative procedure, the use of image intensifiers for localization, the post-operative care of the patient, the clinical results and complications, the histologic appearance, and degree of destruction of the hypophysis are discussed in detail. (auth)

14544 A/CONF.15/P/875

Columbia Univ., New York. Coll. of Physicians and Surgeons.

STEREOTAXIC PLACEMENT OF RADIOACTIVE ISOTOPES IN THE BRAINS OF LABORATORY ANIMALS AND MAN: A STUDY DIRECTED TOWARD THE ALLEVIATION OF PARKINSONISM. James B. Campbell, Harald H. Rossi, and S. Boyesen. 6p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The ideal of stereotaxic neurosurgery is the production of precisely located subcortical lesions in the brain which are predictable in size and shape and gradual in development. The latter qualification is mandatory when dealing with a physiologically sensitive area. Laboratory evidence indicated that these qualifications can be met by the use of accurately calibrated sources of pure beta radiation eminating from 0.86 mm spheres, when delivered by appropriate apparatus. Pd^{109} and Y^{90} were the isotopes used, the latter is bound in a quartz matrix by fusion. Temporal and volumetric data were derived from studies of supravitally stained cats' brains at selected periods after exposure to known doses of beta radiation in supposedly vital structures. Factors influencing lesion size, in addition to source strength, are maximum energy of the beta ray, half life, and self-absorption of radiation within the spheres. At the end of the period of effectiveness of these isotopes, the lesions, which are grossly spherical in shape, consist of a central core which is filled with products of tissue breakdown. The diameter of absolute radium necrosis ranges from one-to 7.5 mm. This is surrounded by a 700 micron-wide zone of irregular transition from necrotic to normal cells. Two hundred and fifty days later, the lesions are sharply localized cysts bound by a 200 micron-wide perimeter of astrocytes beyond which there are no detectable histological changes. When laboratory animals tolerated radiation tissue deficits in sensitive areas which were larger than electrolytic ones which killed others, clinical trial was undertaken with Y^{90}. The limited experiences with human beings suffering from Parkinsonism have prompted development of a technique for controlled deposition of these beta ray sources in subcortical structures in the brain. Details of the method are presented together with clinical data. (auth)

14545 A/CONF.15/P/881

Massachusetts. General Hospital, Boston.

STUDIES ON NEUTRON CAPTURE THERAPY. Gordon L. Brownell and William H. Sweet. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The use of certain neutron-capturing substances combined with thermal neutron irradiation offers many advantages of both external radiation therapy and internal radioisotope therapy. The radiation dose distribution is determined in large measure by the biological properties of the neutron capturing substance. Thus various compounds may be used to improve the distribution. However, as the radiation dose is further limited by the neutron flux distribution, ratios of concentration much less than required for radioisotope therapy may be employed. Further, the short range of certain capture radiations offer the possibility of selective irradiation even on a cellular level. An analysis of the radiation dose resulting from thermal neutron interactions in normal tissue is presented and the total dose rate in a neutron flux of 10^{10} n/cm^2-sec is estimated to be about 47 rad/min. A survey is presented of those nuclides which show promise as capture substances, and normal abundance, cross-section, radiation, range, and average linear energy transfer of the radiation is presented. Finally the amount of the radionuclides required to produce 100 rad/min in a flux of 10^{10} n/cm^2-sec is given. The possibility of using substances with epithermal capture peaks is discussed and calculations presented for certain nuclides. The difficulties in this application are the large amount of material required and the high epithermal flux required. The improvement of thermal neutron distribution by injection of epithermal neutrons is considered. This technique offers considerable promise providing sufficient intensity of epithermal neutrons can be achieved. The results of both theoretical and experimental studies will be presented. Experimental data are to be obtained by means of a crystal neutron spectrometer operating at the medical facility of the Massachusetts Institute of Technology research reactor. The design and use of the crystal device as a neutron spectrometer will be discussed and results presented if available at that time. In particular the effect of variations in crystal reflectivity and higher order reflections on the observed spectra will be discussed. The performance of boron loaded plastic scintillators to be used as detectors will be discussed. Design studies on a semiconductor alpha-particle detector are included. Considerations for the optimal design of neutron apertures for neutron capture therapy are presented. The design of the medical facility at the MIT reactor is discussed and the advantages of certain design features presented. (auth)

14546 A/CONF.15/P/883

Brookhaven National Lab., Upton, N. Y.

RECENT ADVANCES IN NEUTRON CAPTURE THERAPY. L. E. Farr, J. S. Robertson, E. E. Stickley, H. J. Bagnall, O. D. Easterday, and W. Kahle. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Long-term effects of neutron capture therapy, particularly on adjacent normal structures, can now be better predicted on the basis of a comprehensive topographical cytological survey of whole brains. Data at hand appear to confirm the hypotheses previously advanced regarding the very transient accumulation of boron in tumor tissue

and the absence of any specific transport mechanism or affinity for inorganic boron. Widespread destruction to an unusual degree can frequently be demonstrated within the tumor substance. Lack of uniformity of distribution of tumor necrosis is presently explained on inadequate neutron fluxes used and upon uncertainty of exact kinetics of distribution. The anatomical survey points up an as yet unrealized potential for therapy in the procedure. While patient effects have been limited to palliation, in experimental tumors of mice it has been possible to demonstrate a complete suppression of a tumor to maintain itself following neutron capture therapy. Because of exceedingly undesirable skin effects a significant alteration in the manner of administration of the boron was needed. Boron-10 as sodium pentaborate was administered to patients via the ipso lateral internal carotoid artery. No serious complications have thus far resulted, and there is now possible perfusion of tumor with plasma containing several times the boron concentration previously attainable. (auth)

14547 A/CONF.15/P/904
Argonne Cancer Research Hospital, Chicago. and
Varian Associates, Palo Alto, Calif.
A NEW APPROACH TO ELECTRON THERAPY.
Lester S. Skaggs, Lawrence H. Lenzl, and Robert T. Avery. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A combination of a linear accelerator and beam deflection and scanning unit is described which promises to take full advantage of the unique depth dose properties of high-energy electrons. It further provides full flexibility of beam direction in treating a recumbent patient, easy control in selection of field size and shape, conventional single portal as well as revolution therapy, and protection of the patient from stray radiation. (auth)

14548 A/CONF.15/P/2371
California. Univ., Berkeley. Donner Lab.
BIOLOGICAL AND MEDICAL STUDIES WITH HIGH ENERGY PARTICLE ACCELERATORS. J. L. Born, A. O. Anderson, H. O. Anger, et al. 28p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Objective evidence was obtained to show that the course of advanced metastatic mammary carcinoma can be temporarily altered in some patients by massive doses of high energy protons to the pituitary gland. These same doses cause progressive destruction of the pituitary and its function with a minimum of adverse side effects. (auth)

14549 A/CONF.15/P/2401
Division of Biology and Medicine, AEC.
BASIC QUESTIONS IN THE DIAGNOSIS AND TREATMENT OF DISEASE IN MAN USING THE RADIOISOTOPE. C. L. Dunham. 5p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Although the use of radioisotopes in the treatment of disease will never achieve the importance in terms of alleviation of human suffering that tracer use will in unravelling the mysteries of disease processes; nevertheless, for many years to come they will be important weapons in the practicing physician's armamentorium against cancer and selected benign processes. Radiocobalt and radiocesium are now in routine use as radiation teletherapy sources, the former is used as a source of interstitial radiation as well. Parenterally I-131, Au-198 and P-32 are in routine use for several conditions, but with the exception of hyperthyroidism and polycythemia rubra vera this use can hardly be termed definitive treatment. Isotopes have yet to be fully explored in medical diagnosis. With the development of inexpensive low level counting techniques it may be expected that more and more carbon-14 and tritium labelled compounds will be used not only in physiological but diagnostic studies. This should provide much earlier diagnosis of the metabolic defect involved in a variety of "degenerative" diseases and make it possible as these diseases are better understood to take corrective action prior to the occurrence of irreparable damage. (auth)

14550 A/CONF.15/P/2403
Oak Ridge Inst. of Nuclear Studies, Inc., Tenn.
TELETHERAPY: PROGRESS SINCE 1955: TECHNOLOGICAL AND CLINICAL EVALUATION. M. Brucer and N. Simon. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In less than ten years teletherapy has progressed from the idea stage to successful commercial exploitation. About 350 sources from the United States and Canadian producers alone are now being used to treat patients, and this is only cobalt-60. This same rapid development is also occurring for other sources. Cesium-137 sources now are in the developmental stage. Preliminary work has shown that its long half life gives economic advantages; its half-million electron volt radiation does not cause great differences in clinical use but reduces the problem of radiation protection considerably. A third source material, strontium-90, is in the early stage of development. Many other radioisotopes have been used but have some practical disadvantage preventing their exploitation. A serious problem still remains: finding a practical and economical radioisotope in the quarter-million electron volt range. The clinical program with teletherapy has been outstanding. Advantages of teletherapy include skin sparing, decreased bone absorption, and increased depth dose. (C.H.)

Toxicology Studies

14551 A/CONF.15/P/765
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
TREATMENT OF PLUTONIUM INHALATION — CASE STUDIES. W. D. Norwood, P. A. Fuqua, R. H. Wilson, and J. W. Healy. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Treatment of individuals who have inhaled plutonium compounds is apparently even more unsatisfactory than usual if the compound is poorly soluble and slowly absorbed from the lungs. Extended treatment in one case with CaEDTA, increased urinary elimination by a factor of ten but resulted in only ten per cent of the estimated body deposit being eliminated by this route. This study indicates the need for continued research to secure an effective method of treatment. The most exhaustive control methods must be used to prevent plutonium deposition. (auth)

14552 A/CONF.15/P/1008
Montefiore Hospital, New York.
RADIOSTRONTIUM METABOLISM AND DECONTAMINATION IN MAN; CHELATION IN BIOLOGY AND MEDICINE. Daniel Laszlo and Herta Spencer. 32p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Data are summarized from a series of studies involving a total of 70 patients on the metabolism of intravenously and orally administered radiostrontium, on decontamination using various chelating agents, and on tracer studies on the comparative metabolism of strontium and calcium. (C.H.)

Tracer Applications

14553 A/CONF.15/P/392
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
ABSORPTION OF CESIUM-137 BY COMPONENTS OF AN AQUATIC COMMUNITY. Robert C. Pendleton and Wayne C. Hanson. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Results are reported from studies on the uptake of radioactive cesium made by radiochemical analyses of field collections from an impoundment contaminated by fission products from a separations plant, and controlled experiments with cesium-137. Although uptake of this element from soils by terrestrial plants is low, concentration factors of more than 5000 are demonstrated for aquatic organisms. Sorption by the biota coupled with adsorption on inorganic surfaces removed 95% of the original contamination within two days, and 99% within six days. Absorption rates varied according to habitual and trophic levels. Algae and other submerged plants became radioactive very rapidly, and animals feeding on these plants also had a high rate of uptake, since they were getting cesium from three routes, i.e., that absorbed by the plant, that absorbed on the plant surfaces, and from direct sorption. Carnivorous forms accumulated the element at a slower rate, and emergent plants had the least rapid build up. The rate of uptake was not related to ultimate contamination levels in many forms. The effect of trophic levels upon the degree of contamination is discussed, and the routes through which cesium-137 may be transferred from the aquatic environment to terrestrial forms are delineated. Comparative levels of contamination reached by twenty-seven representative aquatic species under experimental and field conditions are reported. The maximum deposition site for Cs^{137} was in the gonads of fish, muscle of frogs and waterfowl, and roots and plants. The results of these studies indicate that cesium–137 is more mobile under aquatic conditions than in soils. Also, the availability of cesium–137 at levels approaching its accepted MPC in drinking water results in unsafe contamination of fish, frogs, waterfowl, and forage that might be consumed by domestic animals. (auth)

14554 A/CONF.15/P/401
Oak Ridge National Lab., Tenn.
STRONTIUM-90 AND CESIUM-137 UPTAKE BY VEGETATION UNDER NATURAL CONDITIONS. S. I. Auerbach and D. A. Crossley, Jr. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The strontium-90 and cesium-137 movement from soil to man is one of the complex problems arising from reactor operations. Most of the information on the plant to soil relationships of these two fission products has been obtained from laboratory experiments utilizing nutrient solutions, prepared soils, and soils contaminated by weapons fallout. Little work has been done on these relationships with plants grown under field conditions. Long-term studies on permanent areas contaminated with these radionuclides have not been reported. Oak Ridge National Laboratory has an area which is uniquely suited for long-term studies under field conditions. This area was formerly a 40-acre radioactive waste impoundment (White Oak Lake) which for 12 years received a continuous input of low-level radioactive wastes. Two years ago the basin was drained, leaving about 35 acres of contaminated terrain. The resulting soil in this area can be characterized as a relatively unconsolidated alluvial sediment, heterogeneous in composition, calcareous, somewhat saline, and alkaline in reaction. Concentrations of strontium-90 and cesium-137 in the first six inches range from 0.02 to 0.29 and from 0.5 to 2.0 microcuries per 100 grams of soil, respectively. Significant concentrations of cobalt-60, ruthenium-106, cerium-144, and the trivalent rare earths are present also. The $\mu\mu$cSr-90 to 1 gram Ca^{*} and the $\mu\mu$cCs-137 to 1 gram K ratios in the leaves of one of the native plants (Polygonum lapathifolium L.) on the lake bed ranged from 5.64×10^{3} to 1.91×10^{5} and from 7.73×10^{4} to 1.67×10^{5}, respectively. As a part of the investigations of uptake by vegetation, four common varieties of corn (Zea mays), namely, Hickory Cane, Aristogold Hybrid, Golden Bantam, and Country Gentleman, were planted in a part of the lake bed laid out in a latin square. Chemical and radiochemical (particularly strontium-90) analyses for the corn plants and native vegetation have not yet been completed nor have the data as yet been given a thorough statistical analysis. However, the first results indicate that the concentrations of cesium-137 may differ between plant organs. The cesium-137 to potassium ratios in the leaves, husks, cobs, and grain have the following ranges: Leaves, 2.93×10^{4} to 5.87×10^{4}; husks, 2.18×10^{4} to 4.18×10^{4}; cobs, 1.76×10^{4} to 2.0×10^{4}; grain 1.54×10^{4} to 1.84×10^{4}. These data indicate a considerable discrimination against cesium-137 on the basis of 1 N ammonium acetate soil extractions of these cations. The strontium-90–calcium ratios obtained in this calcareous soil varied with the mode of extraction of these cations. The range of variation compares favorably with that reported by other workers. (auth)

14555 A/CONF.15/P/402
Woods Hole Oceanographic Institution, Mass.
BIOLOGICAL FACTORS DETERMINING THE DISTRIBUTION OF RADIOISOTOPES IN THE SEA. B. H. Ketchum and V. T. Bowen. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

With the increase of peaceful uses of atomic energy the addition of radioisotopes to the sea, whether intentionally as a waste disposal measure, or accidentally, is inevitable. Many of the radioisotopes will be incorporated in the biological system and will be transferred from organism to organism in the various steps of the food chain. The sinking of organisms and their active migrations both vertically and horizontally in the sea will modify the distribution to be expected from considerations of physical transport alone. The degree to which various radio nuclides will enter the biological system will depend upon the element involved, upon the species of the organisms present in the water, and upon the rate of change of the population of organisms. Different organisms concentrate various elements to various degrees. In the open sea the microscopic and near microscopic plankton organisms make up the majority of the bio-mass, and the entire food chain is based upon the photosynthetic activity of the phytoplankton. Extensive studies of the photosynthetic activity of the phytoplankton population are already underway, but we still have much to learn concerning the factors which deter-

mine and control the rate of growth of such populations. The zooplankton populations of the oceans not only constitute the majority of the animal bio-mass, but also offer a wide variety in phyla and species. Enough is known concerning the content of various trace elements in the ash of a few planktonic species to indicate that between species variations as much as a thousand-fold may be expected in the concentration of individual elements. The transport of elements in the sea will involve not only the physical transport as a result of currents and mixing, but also the biological transport as a result of the accumulation of the elements in organisms and their vertical and horizontal migration. To evaluate the quantitative transport of radioisotopes by the biological system it is necessary to know the bio-mass or quantity of organisms present, the concentration factor of the element in the organism relative to the concentration in the water, the specific activity of the radioisotope in the water, the rate of exchange of the isotope between the organism and the water, and the time the organism is present in the contaminated area and in an uncontaminated area. Our basic knowledge on all of these questions is inadequate to evaluate what the biological system will do to any radioisotopes added to the sea. Using the information that is available one can compare the transport by the biological system with that induced by the physical processes under a variety of hypothetical conditions. Such calculations show that under certain typical conditions in the sea, particularly in well stabilized areas where biological productivity is high, the vertical transport by the migration of organisms is more important in determining the ultimate distribution above and below the thermocline than are the physical processes. (auth)

14556 A/CONF.15/P/811
Missouri. Univ., Columbia.
FACTORS AFFECTING THYROID ACTIVITY IN DOMESTIC ANIMALS AS SHOWN BY RADIOIODINE (I^{131}). G. W. Pipes, B. N. Premachandra, and C. W. Turner. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Methods have been described for estimation of the thyroid secretion rate in cattle and chickens. Comparisons have been made of the relationship of thyroidal-I^{131} release rates with and without goitrogen to thyroxine secretion rate. Little or no relationship was observed. Since release rates also showed poor correlation with ambient temperature, it is believed that thyroid secretion rate is the only reliable method for determination of thyroid function. The thyroid secretion rate of dairy cattle was found to vary from 1.0 to 10.0 mg of 1-thyrozine per 1000 lbs body weight during winter and from 1.0 to 4.0 mg during summer. On an average, thyroid secretion rates were depressed during summer to 30% of the winter value. Estrogen and progesterone in amounts sufficient to stimulate udder growth did not affect thyroid function but estrogen at levels sufficient to induce lactation tended to increase thyroid activity. The mode of inheritance of thyroid secretion rate is being studied in two strains of New Hampshire chickens with widely varying thyroid secretion rates. (auth)

14557 A/CONF.15/P/812
California. Univ., Davis. [Coll. of Agriculture. Dept. of Animal Husbandry.]
SPECIFIC OXIDATION AND UTILIZATION OF ACETATE AND GLUCOSE BY COW, SOW, DOG, AND CHICKEN. Max Kleiber, A. L. Black, J. O. Gütte, and J. R. Luick. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experiments with intravenous injection of acetate-C^{14} and glucose-C^{14} in cows, sows, dogs, and chickens are described. Measurements of C^{14} in respiratory CO_2, in milk, and eggs yielded information about metabolism and milk and egg production in these animals. (T.R.H.)

14558 A/CONF.15/P/813
Maryland. Univ., College Park.
INTERMEDIARY METABOLISM IN THE RUMINANT INCLUDING STUDIES ON RUMEN, LIVER AND LACTATING UDDER. J. C. Shaw, S. Lakshmanan, A. C. Chung, E. C. Leffel, and R. N. Doetsch. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A survey of studies on the metabolism of the ruminant using C^{14}-labeled substrates is presented. (T.R.H.)

14559 A/CONF.15/P/816
New York. State Univ. Veterinary Coll., Ithaca.
QUANTITATIVE STUDIES ON SKELETAL ACCRETION IN LABORATORY AND DOMESTIC ANIMALS. R. H. Wasserman. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In all animals there are two processes occurring simultaneously in the skeleton: —bone accretion and bone resorption. The net increase in bone is equal to bone accretion minus bone resorption and can be determined by gross measurements of bone growth. Until the use of radiotracer techniques it was not possible to measure each process separately. There are two general methods whereby accretion and resorption data can be obtained. Both methods were initially worked out with the rat. The first procedure is based on a combination of balance and radiotracer techniques. The principle is, as follows: radiocalcium (Ca^{45}) is incorporated into the diet or drinking water of the experimental animal, and the intake of dietary calcium and Ca^{45} measured. After a short period on this labeled diet, the rat is killed and the retained skeletal Ca^{45} determined. Total bone growth, or accretion, is equivalent to the amount of Ca^{45} retained in the skeleton divided by the specific activity (SA = Ca^{45}/Ca^{40}) of the diet. When, under conditions of continuous Ca^{45} ingestion, the integrated, plasma specific activity curve and retained skeletal Ca^{45} were employed for this calculation, similar values were obtained. Bone resorption values are determined by difference between the calculated accretion values and net bone growth measured by conventional methods. In the second method, Ca^{45} is parenterally administered in a single dose, and bone accretion estimated from the Ca^{45} disappearance curve and retained Ca^{45}. Mathematical analysis of this kind of data has indicated that the movement of Ca^{45} into bone by accretion can be distinguished from that due to exchange reactions; accretion rates can thus be calculated. These methods have been used for preliminary calculations of bone accretion and bone resorption in domestic animals since such values are not available in the literature. (auth)

14560 A/CONF.15/P/820
Resources Research, Inc., Washington, D. C. and Georgetown Univ., Washington, D. C. Medical Center.
RAPID BACTERIOLOGICAL DETECTION AND IDENTIFICATION. Gilbert V. Levin, Venton R. Harrison, Walter C. Hess, A. H. Heim, and V. L. Stauss. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Public health considerations in controlling the quality of municipal water supplies, packaged foods and dairy products have long required the development of more rapid methods for making bacteriological determinations. While considerable effort has been directed toward this goal in the past, progress has been retarded by the fact that the bacteria or their metabolic products must be seen by the naked eye in all currently standard methods. In order for the cells of their products to become visible, a minimum of 20 hours must lapse while the organisms undergo intensive growth and reproduction. More frequently, the tests, such as those generally used in examining drinking water, require 48 to 72 hours for completion. This represents a dangerous lag in important public health control measures and might allow contaminated water to be widely consumed throughout a community, as, indeed, has often occurred. The incorporation of radioactive isotopes into bacteriological media and the subsequent detection of the label in the bacteria or metabolic products is suggested to enable the test time to be reduced to several hours or even to a matter of several minutes. The authors have been working to develop a rapid test for coliform organisms in drinking water. These organisms, associated with sewage, constitute the index of sanitary quality of water. Lactose–1-C^{14} has been incorporated into standard lactose broth medium and used in the standard method for the presumptive test for coliform organisms. The sample of water is filtered with a membrane filter and the filter containing the organisms is immersed in the radioactive medium. The organisms immediately begin utilizing the lactose and respiring $C^{14}O_2$ which is evolved and trapped as barium carbonate. The presence of radioactivity in the CO_2 trap satisfies the criteria for the presumptive presence of coliform organisms, namely, the fermentation of lactose with the production of gas. Success with this test in frequently producing results within a total elapsed time of less than one hour with 100 cells or less, led to an attempt to develop a direct confirmed coliform test. Radioisotopes were used in two standard confirmed media, brillant green bile broth and formate ricinoleate broth. A successful confirmed test would enable water works plants to monitor the quality of water as it is produced and take prompt action when contamination appears. It is also hoped that a simple field kit will be developed so that health officials in areas where laboratories are not immediately available will be able to make on-the-spot bacteriological determinations. Other isotopes such as S^{35} have or may be used in general or specific bacteriological tests. Requiring only several microcuries of activity per test, the method could be used in the field or laboratory without special protective measures or devices. Although initially expensive, the method now competes favorably with the standard methods from the point of economics. There may also be a potential use for the method in clinical medicine where rapid identification of infectious agents may allow selection of the specific drug of choice. (auth)

14561 A/CONF.15/P/835
Arkansas. Univ., Fayetteville.
THE TRANSPORT OF PHOSPHATE ACROSS CELL MEMBRANES. Jacob Sacks. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Evidence has accumulated from a number of tracer studies that the entrance of phosphate into the cell interior takes place by active transport processes involving thermodynamic work, and presumably enzymatic action, rather than by simple physical diffusion. The common conclusion reached from these studies is that the principal means by which this transport takes place is through the formation of adenosine triphosphate (ATP) on the cell membrane, from orthophosphate present in the extracellular phase and either adenosine diphosphate (ADP) or adenosine monophosphate (AMP) present within the cell interior. In addition, there is evidence that the formation of phosphocreatine on the cell membrane plays an important part in the transport of phosphate into those tissues which contain significant quantities of this substance. Some observations on mammalian muscle also indicate that inorganic pyrophosphate may be involved in the transport process. Great variations have been found between different tissues with respect to the rate of the transport process. The transport process is extremely slow in mammalian muscle and does not appear to vary greatly between mammalian and frog muscle. The isolated diaphragm, however, appears to have a much higher transport rate than ordinary skeletal muscle. In the heart the transport rate is many times that in striated muscle, and in liver and kidney the rate is extremely high. Species differences have been found in the transport rate in liver, and even some differences between genetically distinct strains of rats. Muscular activity has been found to have no measurable effect on the rate of phosphate transport; however, there is an increased rate in the recovery period. In the case of nerve, evidence has been obtained that suggests an actual inhibition of phosphate transport into the fiber during prolonged stimulation. (auth)

14562 A/CONF.15/P/836
Rochester, N. Y. Univ.
ISOTOPES AND PARATHYROID FUNCTION. W. F. Neuman, H. E. Firschein, G. R. Martin, and B. J. Mulryan. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Largely through the use of isotopes our understanding of the surface chemistry and chemical properties of bone mineral has increased greatly. With this increased knowledge, it has been possible to resolve the classical arguments concerning the state of saturation of serum with respect to bone mineral. Physicochemically, only one conclusion seemed reasonable: the fluids bathing the bone crystals must differ in composition from that of serum. If this be true, i.e., there exist ion-gradients between bone and the circulation, the composition differences must arise from localized cellular activity and it follows that the parathyroid secretions, which affect the state of saturation of serum, must influence the metabolic activity of the bone cells. The problem remaining was an experimental one: how to demonstrate the existence of parathyroid-regulated cellularly-maintained concentration gradients between bone and serum. Classically, the physiologist has used arteriovenous differences to establish such localized organ-specific events, but bone does not have a convenient vein for cannulation. Again, isotopes offered the solution. A new technique was devised wherein a hole was drilled into the femoral spongiosa of an intact heparinized dog, the hole was cannulated, and the collected blood was taken for comparision with simultaneous arterial samples. By the administration of Sr^{89}, which deposits exclusively in bone, a strontium clearance was obtained. This clearance gave a rough measure of the proportion of the mixed blood which was venous outflow from bone. By this means, it was possible to demon-

strate that, in the normal animal, there exist high local concentrations of citrate in bone. In fact, bone appears to be one of the principle sources of circulating citrate. Parathyroidectomy nearly abolished citrate production bone, while injection of parathyroid extract caused an outpouring of citrate and other acids, notably lactate. Thus, the gross biochemical mechanism of parathyroid function begins to become clear. A review of the existing literature suggests that our present information on parathyroid action is entirely compatible with this new concept and a number of critical new experiments are suggested. (auth)

14563 A/CONF.15/P/837

Indiana. Univ., Bloomington.

THE METABOLISM OF ISOTOPICALLY LABELED PLASMA PROTEINS. Felix Haurowitz, Sidney Fleischer, Harry Walter, and Arthur Lietze. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Most of the published work on the metabolic fate of homologous plasma proteins is limited to the determination of their rate of disappearance from the circulation. In our own work the metabolism of normal proteins and particularly their utilization for the formation of organ proteins was investigated. Rabbits and rats were injected with doubly labeled homologous serum albumin, containing S-35 amino acids and either traces of I-131 or C-14 amino acids. Using a parenthesis to denote "internal" labeling we designate the two types of rat serum albumin as RtA(S*)I* and RtA(S*, C*) and the analogous globulins as RtG. The blood plasma and the organs of the injected rats were analyzed various times after the injection of the labeled protein. When RtA(S*, C*) or RtG(S*, C*) are injected, the ratio S*/C* in the proteins of liver, lung, spleen, and muscle is not very different from that of the injected material. Evidently, S-35 amino acids and C-14 amino acids are reincorporated at a similar rate. The S*/C* ratio in the hair keratin is about 3 times higher, due to the high sulfur content of keratin. Keratin is a particularly favorable object for studies on protein formation since its formation is a one-way reaction, not complicated by simultaneous breakdown. This allows us to measure the specific activity of the protein formed at any time after the injection of isotopically labeled proteins. The high S*/C* ratio in keratin proves convincingly that the conversion of the injected (S*C*)-serum proteins into keratin does not involve significant utilization of large peptide fragments, but that most of the injected serum protein is first degraded to amino acids which are then utilized for the biosynthesis of keratin. After the injection of RtA(S*)I* the S*-activity of serum and organ proteins is the same as after injection of RtA(S*, C*). However, the I*-activity of the organ proteins decreases rapidly so that the ratio S*/I* in the organ proteins on the 9th day after injection is about 50 to 100 times higher than the S*/I* ratio in the injected RtA(S*)-I*. In the serum proteins the ratio S*/I* increased only slowly to a value of about 5 after 9 days due to the formation of new S^{35}-serum protein. Our experiments show that the rate-determining step in the metabolism of the plasma proteins is their slow passage into the tissue cells where they seem to be degraded rapidly to the amino acid stage. While I* is excreted, S*- and C*-amino acids are reutilized for the synthesis of new tissue and plasma proteins. (auth)

14564 A/CONF.15/P/839

Harvard Univ., Boston. Medical School.

USE OF C^{14} IN QUANTITATIVE STUDIES OF ALTERNATE METABOLIC PATHWAYS. James Ashmore and A. Baird Hastings. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Using a method of alternate substrate labeling we calculated the rate of glucose phosphorylation in liver slices from normal, diabetic, adrenalectomized, adrenalectomized-diabetic, cortisone treated and insulin treated rats. Results are summarized. It is apparent from the results that in the absence of insulin hepatic glucose phosphorylation is markedly reduced. The presence and absence of adrenal cortical steroids appears to make no significant difference in the rate of glucose phosphorylation. However, injection of insulin in normal animals causes an increase in hepatic glucose phosphorylation. (auth)

14565 A/CONF.15/P/840

Brookhaven National Lab., Upton, N. Y. and National Institutes of Health, Bethesda, Md.

DYNAMICS OF HEMOPOIETIC PROLIFERATION IN MAN AND MICE STUDIED BY ^{3}H-THYMIDINE INCORPORATION INTO DNA. E. P. Cronkite, T. M. Fliedner, V. P. Bond, J. R. Rubini, G. Brecher, and H. Quastler. 25p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Tritiated thymidine has been used in animals, and in human beings with normal and abnormal hematopoiesis to study the kinetics of bone marrow cell proliferation. Thymidine is taken up by the nucleus only during DNA synthesis preparatory to cell division. Its intracellular location was determined and quantified by means of stripping film autoradiography and classical cytology. In the bone marrow of human beings with normal hematopoiesis given H^3 thymidine intravenously, intense labeling of primitive proliferating cells was seen within minutes. Maximal labeling of erythorocyte precursors occurred at 12 to 24 hours; myeloid precursors between the 3rd and 4th day. Maximal labeling of megakaryocytes was observed on the 5th day. Early labeling in the peripheral blood of large mononuclear cells occurred early; the peak labeling of granulocytes occurred on the 5th and 6th day. H^3 thymidine incubated with normal human bone marrow resulted in heavy labeling in all cell series; normal venous blood showed labeling only of a small percent of the large mononuclear cells. The pattern of H^3 thymidine uptake with in vitro incubation of bone marrow and venous blood from patients varied with different hematopoietic disorders. A preliminary analysis of the quantitative results in terms of the kinetics of hematopoietic cell proliferation in health and disease is made, and the requirements for resolution of the complex problems involved are pointed out. (auth)

14566 A/CONF.15/P/842

Brookhaven National Lab., Upton, N. Y.

AUTORADIOGRAPHY WITH TRITIUM. THE DUPLICATING MECHANISM OF CHROMOSOMES AND THE CHRONOLOGY OF EVENTS RELATED TO NUCLEIC ACID SYNTHESIS. W. L. Hughes. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The very short range of the β^- radiation from tritium permits high resolution in autoradiography. Tritium carried in thymidine has been used to label deoxyribonucleic acid in plants, animals, and bacteria. These studies have shown that genetic material is transmitted intact as half-chromosomal units during cell division. This suggests a replicative mechanism for chromosomes which consists of the separation of each chromosome into complementary halves with the formation of

new complements upon the existing halves as templates. The use of tritium-labeled nucleic acids in studying the chronology of related cell processes is reviewed. (auth)

14567 A/CONF.15/P/845

California. Univ., Berkeley. Radiation Lab.

STUDIES ON METABOLIC DYNAMICS WITH CARBON FOURTEEN AND PHOSPHOROUS THIRTY-TWO AS TRACER ATOMS. J. A. Bassham and K. K. Lonberg-Holm. 13p. (UCRL-3985). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Use of suspensions of unicellular green algae, and employment of both $C^{14}O_2$ and $H_3P^{32}O_4$ substrates, made it possible to trace the route of carbon through the carbon-reduction cycle of photosynthesis and to measure the concentrations of many of the intermediates in this cycle. Furthermore, exact measurements of these concentrations at various rates of CO_2 uptake which are also measured make possible a quantitative treatment of the reaction kinetics of the carbon-reduction cycle during steady-state photosynthesis. Experiments have been made on free-cell suspensions of mouse ascites tumor cells with the aid of $H_3P^{32}O_4$ and high-specific-activity glucose C^{14}. Following the addition of glucose substrate, it has been possible to measure the rapid appearance of glycolytic intermediates and a concomitant fluctuation in nucleotide polyphosphate concentrations. In the seconds following glucose addition transient behavior occurs while the rates of individual reactions are adapted to the presence of external substrate. After about one minute the cell achieves metabolic control and the concentrations of internal intermediates remain fixed at steady-state values. (auth)

14568 A/CONF.15/P/846

Massachusetts. General Hospital. John Collins Warren Labs., Boston.

STUDIES ON THE MECHANISM OF PROTEIN SYNTHESIS. Robert B. Loftfield, Paul C. Zamecnik, Liselotte I. Hecht, Mary L. Stephenson, Mahlon B. Hoegland, John W. Littlefield, and Elizabeth B. Keller. 6p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The biosynthesis of protein was studied in vivo, in surviving tissue preparations and in cell-free homogenates using carbon-14 labeled amino acids. It has been found that free amino acids are the precursors of new protein, i.e., that in general, one protein molecule is not converted into another except through the free amino acid pools. The assembly of free amino acids to yield protein appears to proceed in at least four steps. In the first step the amino acid reacts with adenosine triphosphate in the presence of a soluble cytoplasmic enzyme to yield the amino acyl adenylate. We have prepared C-14-valyl adenylate from C-14-valine in such a system. Amino acids activated in this way then are transferred in a still obscure way to a relatively low molecular weight ribonucleic acid (RNA) of the cytoplasm. The amino acid attached to the RNA is still activated (i.e., capable of reacting with hydroxylamine to give hydroxamic acids) and can be removed with RNAase or alkali. It is definitely not bound in peptide chains. In the presence of guanosine triphosphate, the labeled amino acid is transferred from the soluble cytoplasmic RNA to the ribonucleoprotein particles. At this point the amino acids appear to form peptide chains and are no longer bound covalently to the ribonucleic acid. Ribonucleoprotein particles labeled in vitro with C-14-amino acid have not yet yielded any identifiable or functional labeled protein. In vivo studies have in general supported the idea that the above sequence of steps is biologically significant. If C-14-amino acids are injected intravenously into rats and sections of the liver are removed at various intervals, it is found that radioactivity first appears in the free intracellular amino acid pool. The soluble RNA fraction is maximally labeled in less than a minute and the ribonucleoprotein particles are maximally labeled in 3 to 5 minutes. Radioactive protein then appears to accumulate in the lipoprotein fraction of the microsomes whence it is released into the cell or secreted. If a single well characterized protein such as ferritin is isolated, we find that the protein is slightly labeled at the earliest time intervals. However, only after some 6 minutes does the rate of labeling of the ferritin equal the established rate of synthesis, Thus it takes approximately 6 minutes for ferritin to be assembled from the free amino acid pool. The kinetics of the incorporation are consistent with a mechanism in which activated amino acids are assembled in stepwise fashion on a template. (auth)

14569 A/CONF.15/P/847

Argonne Cancer Research Hospital, Chicago, and Chicago. Univ.

STUDIES ON ERYTHROPOIESIS. Leon O. Jacobson, Eugene Goldwasser, Clifford W. Gurney, Walter Fried, and Louis F. Plzak. 24p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The erythropoietic activity of plasma from anemic animals and human beings can be determined by studying the rate of incorporation of Fe^{59} into the red cells of recipient normal rats. Hypophysectomy of rats reduces erythropoiesis to a minimum within 1 to 3 weeks. The reduction is less and occurs more slowly in immature rats than in young adult rats. Hypophysectomized rats are sensitive to anemic plasma, especially during the period (between 1 and 3 weeks) when erythropoiesis is at its minimum. The response of hypophysectomized animals in terms of reticulocyte or Fe^{59} red blood cell incorporation is 2- to-10-fold greater than that in normal rats. Hypophysectomized rats retain the capacity to produce erythropoietin in response to bleeding. Transfusion-induced polycythemia in rats and mice, acute starvation in rats, and hyperoxia in rats, all rapidly reduce erythropoiesis. Experimental animals in these conditions are sensitive in their response to the injection of erythropoietin. The rate of erythropoiesis, as determined by the quantity of circulating erythropoietin depends on the relationship of oxygen supply to oxygen demand in the tissue rather than to either factor acting alone. Injection of cobaltous chloride increases the erythropoietin titer in the plasma of rats and rabbits within 10 to 12 hours. After bilateral nephrectomy, Co^{2+} administration, acute hemorrhage, or hypoxic hypoxia fails to elevate plasma erythropoietin, whereas bilateral ureter ligation reduces but does not eliminate the erythropoietin plasma elevation. After removal of adrenals, gonads, stomach, intestines, spleen, pancreas, thymus, or 90 per cent of the liver, an increase in plasma erythropoietin does occur in response to cobalt or bleeding. These observations suggest that the kidney may be the site of erythropoietin production. (auth)

14570 A/CONF.15/P/848

Argonne Cancer Research Hospital, Chicago and Chicago. Univ.

THE USE OF A "SELF-RADIATION" LABELED TRITIUM COMPOUND IN BIOLOGICAL EXPERIMENTATION. James L. Spratt and George T. Okita. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Studies were undertaken on the subcellular localization and protein binding of radioactive digitoxin. Both in vitro and in vivo preparations were used. During the course of this investigation it was demonstrated that self-radiation labeled H^3-digitoxin is as reliable as biosynthetically labeled C^{14}-digitoxin in biochemical tracer studies. Twenty minutes after a single intravenous injection, the rat essentially clears its vascular system of digitoxin with metabolism of a significant amount of the parent compound. Upon cell fractionation of organs from these animals, digitoxin does not show any marked binding with any of the particulate fractions of heart, kidney, and liver cells but appears in the soluble supernate. The results of in vitro experiments agree with the data obtained from the injected animals. Digitoxin binding by serum albumin could not be demonstrated using zone electrophoresis. Using salt precipitation and exchange dialysis methods, results obtained in the present study agree with those of previous workers who found that digitoxin binding by serum proteins is correlated with albumin content. However, correlative explanations other than albumin content are possible. The serum binding capacity of 0.01 μg of digitoxin bound per mg of protein found in this study is much lower than that reported by previous investigators. (auth)

14571 A/CONF.15/P/849

Chicago. Univ. [School of Medicine.]

OBSERVATIONS ON ISOTOPE LABELED DRUGS IN THE CENTRAL NERVOUS SYSTEM. Charles F. Barlow, Joseph C. Schoolar, N. S. Domek, D. W. Benson, and Lloyd J. Roth 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The anatomical distribution of isotope-labeled compounds in cat brain has been studied. The isotope distribution was documented by radioautographs of brain slices, and by dissection of approximately 16 brain areas with subsequent homogenization, plating, and counting in an open window gas flow Geiger counter. The following compounds were studied: C^{14}-isonicotinic acid hydrazide; S^{35}-carbon disulfide; C^{14}-urea; S^{35}-acetazolamide; C^{14}-phenobarbital; S^{35}-thiopental; and I^{131}-albumin (which, because it does not leave cerebral blood vessels, is an indicator of brain vascularity). We are able to conclude that in all of the above compounds, the quantitative distribution pattern follows the anatomical boundaries within brain tissue. Furthermore, although there are general similarities in the concentration of some substances to the magnitude of blood supply of various regions of brain, the correlation is generally weak and in all instances, there are prominent inconsistencies. Each substance studied demonstrates some relatively unique features in the pattern. For example, the relative concentration of isonicotinic acid hydrazide in hippocampus is much greater than the relative vascularity of this structure and increases while other areas of the brain are decreasing. Carbon disulfide (administered by inhalation) produces a pattern of radioautographic density comparable to a myelin stain, while thiopental, another fat soluble agent, produces a similar pattern at one plus hours, but at five minutes after intravenous injection, the greater concentrations are found in gray matter. Acetazolamide is unusual in that early and quantitatively greatest entry into nervous tissue is by way of diffusion from cerebrospinal fluid, while blood to brain transport is quantitatively less. In addition, hippocampus, caudate nucleus, and hypothalamus apparently retain their high concentration of acetazolamide longer than other areas. These observations of individual peculiarities of drug distribution provide clues for further study of the more fundamental physiologic and biochemical mechanisms involved in mediating such differences. Despite the essential interest in the differences mentioned above, in most remaining anatomical units of brain there is an over-all similarity in the pattern of many substances such as urea, isonicotinic acid hydrazide, phenobarbital, and acetazolamide. This would imply the operation of a common factor. It is possible that a study of regional differences in water compartments of brain may explain this common pattern. This investigational approach to the nervous system is regarded as a method by which drugs and other substances are used as indicators of physiologic and biochemical processes in focal anatomical units of brain. We do not assume that the demonstration of a focal concentration of drug implies its site of action. (auth)

14572 A/CONF.15/P/851

Brookhaven National Lab., Upton, N. Y.

ISOTOPIC STUDIES OF ENZYME STRUCTURE AND FUNCTION. D. E. Koshland, Jr. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The understanding of enzyme action is not only fundamental to an elucidation of biological problems but also could lead to new developments in the important field of catalysis. The study of enzymes, however, is complicated by the fragile nature of these compounds and the fact that only small amounts of material are usually available. Isotopic techniques have been found to be particularly useful in this field of investigation and the use of isotopes in two illustrative cases is described. The first example is the use of P^{32} to mark and then map out the active site of the enzyme phosphoglucomutase. Enzymes are high molecular weight compounds containing only a small area which is in direct contact with the substrate. To mark this site and only this site, radioactive substrates, glucose-1-$P^{32}O_4$ and glucose-6-$P^{32}O_4$, were prepared and incubated with enzyme until P^{32}-labelled enzyme was obtained. Tests using protein precipitants and inactive substrates demonstrated that this P^{32} was covalently bound at the active site and that the labelled enzyme was completely active. Furthermore, it was shown that the labelled enzyme could be degraded to small peptides without migration or loss of the isotopic label. In this way it was found that 6 of the amino acids at the active site are aspartic acid, serine, glycine, glutamic acid, alanine and valine. Moreover, comparison with sequences observed in other enzymes suggests that a separation of amino acids into those involved in catalytic function and those involved in specificity function occurs in the protein structure. The second example involves the use of the C^{14}-labelled methanol to elucidate the role of water in the proteins responsible for muscular contraction. Both myosin and a combination of actin and myosin, actomyosin, catalyze the hydrolysis of adenosine triphosphate (ATP), but only the latter undergoes contraction. By theoretical calculations it could be shown that the existence and specificity of a water site on these proteins could be determined if methyl phosphate in the range of 10^{-12} moles could be detected. This amount was well below the range of conventional analytical procedures but could be measured with the use of radioactive methanol. When the appropriate experiments were performed, it was found

that both myosin and actomyosin have water sites and that these sites have similar specificities. The results indicate that the myosin part of actomyosin contains the locus at which water reacts during muscular contraction. (auth)

14573 A/CONF.15/P/852
Western Reserve Univ., Cleveland.
TRACER STUDIES ON THE SYNTHESIS OF MILK CONSTITUENTS. H. G. Wood. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Methods were developed for injecting isotopic compounds directly into the pudic artery supplying one side of a cow's udder after local anesthesia and incision of the abdominal wall. After the injection the incision is closed and the two sides are milked separately at successive time intervals for 18 hours, and the milk of each side is prepared separately to determine the isotope distribution in the lactose, the glycerol of fat, and the serine of casein. By comparison of the injected and uninjected sides, it is possible in a single experiment to study the metabolism of the whole animal as compared to the udder per se. (auth)

14574 A/CONF.15/P/854
Veterans Administration Hospital, Seattle and Washington. Univ., Seattle. School of Medicine.
THE USE OF CARBON-14 FOR THE ELUCIDATION OF A NEW PATHWAY OF LIPIDE SYNTHESIS IN ADIPOSE TISSUE. D. D. Feller. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The literature on lipide synthesis in adipose tissue is surveyed. Carbon-14 tracer studies on lipide synthesis from acetate, from propionate and methyl malonate, and from isoleucine are summarized and a new scheme is proposed. Substantiating data are presented and the interrelationships between acetate, propionate, methyl malonate, and isoleucine in formation of lipides by adipose tissue are explained. (T.R.H.)

14575 A/CONF.15/P/855
Harvard Univ., Boston. Medical School. Biophysical Lab.
METABOLIC CHANGES IN LEUCOCYTES DURING PHAGOCYTOSIS, STUDIED WITH C^{14}. Manfred L. Karnovsky and Anthony J. Sharra. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The data presented indicate that during phagocytosis, polymorphonuclear leukocyte exhibit a marked increase in energy metabolism. It cannot be stated unequivocally that the phagocytic act per se requires energy expenditure on the part of the leukocyte, but it is clear that increased substrate utilization, oxygen consumption, and lactate production always accompany phagocytosis. (auth)

14576 A/CONF.15/P/856
Washington. Univ., Seattle. School of Medicine.
BASIC MECHANISMS OF BLOOD PRESERVATION. Beverly W. Gabrio, C. A. Finch, and F. M. Huennekens. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Contemporary isotopic and enzymatic studies in this laboratory and elsewhere have revealed, contrary to previous beliefs, that the red blood cell has a wide spectrum of metabolic activities, comparable to many other cellular types. Biochemical studies at the molecular level have provided considerable insight into the fundamental nature of certain erythrocytic diseases (hemolytic anemia, congenital methemoglobinemia, etc.) and also have led to the discovery of preservative agents which prolong the useful storage period of blood prior to transfusion. Extended storage of blood is desirable, not only for routine blood banking procedures, but also for emergency situations where stockpiling and transport would be required. Isotopically labeled (C^{14}, N^{15}, P^{32}) substances are employed to map out metabolic pathways, and the isolation of individual enzymes provides information on the mechanism of the various reactions in these pathways. The major energy source of the erythrocyte is glucose, which may be metabolized by anaerobic glycolysis, or the aerobic pentose cycle. An impairment in anaerobic glycolysis appears to be responsible for certain hemolytic anemias, while a malfunctioning enzyme (methemoglobin reductase) in the aerobic pentose cycle is a causative factor in congenital methemoglobinemia. During the in vitro storage of blood, glucose utilization declines, as a prelude to the loss of cellular integrity. Supplementation of stored cells with nucleosides, such as adenosine or inosine, provides an alternate energy source, and hence prolongs the storage of red blood cells, since these materials are broken down to yield ribose phosphate, a component of the pentose cycle. The detailed mechanism of these pathways of glucose and nucleoside metabolism, as explored by enzymatic and tracer techniques, and their relevance to the above physiological problems, are discussed. (auth)

14577 A/CONF.15/P/857
California. Univ., Los Angeles. School of Medicine.
THE METABOLISM OF TRACE METAL IONS. Paul Saltman. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Several pathological conditions in man are characterized by the accumulation of large amounts of various trace metal ions. Prior studies have been directed toward the nutritional aspects of the essential metals, their role in enzyme systems, and their interaction with isolated protein fractions. Little attention has been focused on the mechanisms by which these ions move into and out of cells. The accumulation by biological systems of K^{+}, Mg^{++}, Ca^{++} and other so-called bulk elements as well as many organic compounds is directly coupled to the energy metabolism of the cell, a process called active transport. Our studies on trace metal uptake and efflux indicate the operation of an entirely different mechanism which is passive and not linked to metabolic energy. The use of radioactive tracers such as Fe^{59}, Cu^{64}, and Zn^{65} has permitted us to study many properties of the systems involved in trace metal metabolism. Slices or cell suspensions from liver, kidney, spleen and other tissues were incubated under various chemical and physical environments in buffer solutions containing the ion under investigation. The rate of net uptake of the ion is directly proportional to the tracer, permitting simple analytical procedures to be employed. Several cytological observations indicate new areas for trace metal investigations. Radioautographs of liver cells exposed to Fe^{59} clearly demonstrate that the nucleus is the initial locus of iron uptake. Doubt as to whether the membrane is involved in trace metal transport is raised by the lack of effect of detergents or other techniques designed to rupture cell membranes. The nature of the specificity of the binding sites has been studied by exposing the tissue to many isotopes simultaneously and measuring each isotope independently with a pulse height analyzer. Parallel

investigations led to the isolation by electrophoresis of the iron binding proteins from human liver at autopsy. A new and as yet incompletely characterized protein, as rich in iron as ferritin, was found in those livers where abnormal iron metabolism was indicated. Our findings show a close correlation at the molecular level between pathological aberrations of trace metal distribution and changes in either the amount or kinds of binding sites within the affected cells. (auth)

14578 A/CONF.15/P/860

Argonne National Lab., Lemont, Ill.; Argonne Cancer Research Hospital, Chicago; Suburban Cook County Tuberculosis Hospital-Sanitarium, Hinsdale, Ill.; and Chicago. Univ.

THE BIOLOGY OF DEUTERIUM. J. J. Katz, H. L. Crespi, A. J. Finkel, R. J. Hasterlik, J. F. Thomson, W. Lester, Jr., W. Chorney, N. Scully, R. L. Shaffer, and Sung Huang Sun. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

That replacement of hydrogen by deuterium has far-reaching consequences for living systems has long been noted, but the full scope and nature of these effects still remain largely unexplored. Early work was greatly hampered by the difficulties of obtaining deuterium but the development of a vast nuclear energy technology has made deuterium available on a large scale. It has now become opportune to undertake comprehensive studies on the biology of deuterium, and this paper reports work undertaken on algae, fungi, bacteria, and mammals. Mice will tolerate up to about 40 per cent D_2O in the drinking water for at least four months; during this period the body water reaches a stable value of about 30 per cent heavy water. When deuteration is continued for long periods, deuterium is incorporated into various tissues and organs to the amount of from 40 to 50 per cent of the deuterium in the body fluids. Mice have been maintained in a deuterated state, up to 25 atom per cent, for as long as 12 months without obvious effects, although there are some indications that fertility is adversely affected. The basis of the biological effects of deuteration is the kinetic isotope effect. In general, bonds to deuterium react less readily than bonds to hydrogen; in consequence, reaction rates are decreased, and a depression in tissue metabolism should result. At concentrations above 30 atom per cent deuterium mice and rats show weakness, neutrmuscular hyperexcitability, bradycardia, and eventually, stupor and death. Since neoplastic cells metabolize rapidly, presumably these should be particularly sensitive to the effects of deuteration. Deuteration of host mice resulted in reduced growth rates of injected Krebs-2 ascites tumors and of inoculated P-1534 lymphatic leukemia. The general effects of deuterium on growth has been studied in algae and fungi. Two species of algae, Chlorella vulgaris and Scenedesmus obliquus, have been successfully cultured in nutrient media containing 99.6 per cent D_2O. Growth rates are inhibited, but algae have been harvested that yield water of combustion containing more than 90 atom per cent deuterium. The morphology, pigmentation and granulation of the algae were altered by deuteration. The fungi Penicillium notatum and Aspergillus fonsecaeus have been grown in media containing various concentrations of D_2O up to 99.6 per cent, and here, too, morphology, sporulation, pigment production, and growth rate were all affected by deuteration. The results obtained with algae clearly indicate the feasibility of producing fully deuterated compounds of biological significance by biosynthetic procedures. Bacterial studies on Group C hemolytic streptococci, Type I pneumococci, Mycobacterium tuberculosis and M. phlei, and Escherichia coli showed that the growth rates were diminished with elevation of the D_2O concentration above 50 per cent and that cessation of growth uniformly occurred at D_2O levels greater than 90 per cent. Deuterium may also be utilized in the study of metabolism by the administration of deuterated essential metabolites. Experiments are described wherein fungi have been grown on glucose in which the hydrogen on carbon-1 (D-glucose-d_1) has been completely replaced by deuterium. (auth)

14579 A/CONF.15/P/861

Argonne National Lab., Lemont, Ill.

THE USE OF DYNAMIC ISOTOPE METHODS IN STUDIES OF PROTEIN SYNTHESIS. Robert W. Swick. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The technique of continuous administration of tracer materials to animals makes it possible to determine precursor-product relationships and to measure quantitatively the velocities of some metabolic reactions. This report describes the results of experiments designed to establish whether or not the concept of metabolic turnover applies to rat liver proteins. Since it was concluded that the concept does apply, the average rate of turnover of these proteins was measured. The relationships of the rate to growth, diet, and endocrine status were also studied. (auth)

14580 A/CONF.15/P/863

Rochester, N. Y. Univ. School of Medicine and Dentistry.

STUDIES DIRECTED TOWARD THE USE OF ANTIBODIES AS CARRIERS OF RADIOACTIVITY FOR THE THERAPY OF CANCER. William F. Bale, Irving L. Spar, and Ruth L. Goodland. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Radioactive antibodies to the Murphy-Sturm rat lymphosarcoma were prepared that after intravenous injection into rats bearing this tumor led to highly preferential localization of radioactivity in tumor tissue. The antibodies were isolated from serum obtained from rabbits immunized against this tumor, and made radioactive by in vitro coupling to I^{131}. It is believed that by techniques reported here selective tumor radiation doses in the therapeutic range can be achieved. (auth)

14581 A/CONF.15/P/865

California. Univ., Los Angeles.

OBSERVATIONS FOLLOWING EXPERIMENTAL INTRALARYNGEAL INJECTION OF RADIOISOTOPES ($CrP^{32}O_4$; $Cr^{51}P^{32}O_4$). Joel J. Pressman, Andrew H. Dowdy, Raymond L. Libby, Max Fields, M. B. Simon, and K. Hand. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Radioactive chromic phosphate tagged with radiochromium and radiophosphorous was introduced in varying concentrations by multiple injections and its spread throughout the larynx observed. The larynx was scanned at selected intervals up to eight weeks. If injected on only one side of the larynx no crossover to the opposite side took place within this period. Studies were made of the fate of the injected isotope. Small amounts appeared in the blood stream in a matter of minutes but this cleared in a few hours. No spread downwards into the trachea was observed. Within 24

hours after injection, counts taken over the larynx indicated a loss in radioactivity by spread into other parts of the body of approximately 25%. Part of this fraction was recovered in the lymph nodes of the neck and smaller fractions in the liver and spleen. No further loss of radioactivity was noted during the next eight weeks. Radioactivity in appreciable amounts remained in the lymph nodes of the neck for this period of observation but more was observed in other adjacent tissues. Essentially all the injected material has been accounted for and its fate in the body will be described. The smallest amount of radioactive isotope considered cancerocidal i.e., approximately 10,000 rem per gram of tissue was well tolerated by the dog's larynx. When the concentration was increased to as much as 60,000 rem per gram, ulceration and necrosis often amounting to complete destruction, occurred. Studies of the effects of intermediate dosages are in progress. Certain details of the observed spread of injected fluids including radioisotopes resulted in the observation that the larynx was divided into submucosal compartments essentially independent of each other. This required that a pattern of injection by areas be developed to assure for purposes of therapy, the proper dissemination of radioisotopes. This pattern and suggested dosage for clinical trials are described, and illustrated by slides. The patterns of submucosal compartmentation as observed in these studies, when correlated with the clinical distribution of cancer of the larynx, suggest that on the basis of these finds the local route of spread of cancer of the larynx can be predicted. These studies with radioisotopes have been confined by the use of dyes, permitting visual demonstration of the phenomenon observed. Approximately 150 dogs were used in the experiments which were augmented by observations on a few humans and in experimental pigs. (auth)

14582 A/CONF.15/P/866

National Heart Inst., Bethesda, Md.

A NEW DIAGNOSTIC METHOD IN THE STUDY OF CONGENITAL HEART DISEASE: THE KRYPTON^{85} TEST FOR CIRCULATORY SHUNTS. Richard J. Sanders and Andrew G. Morrow. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A new method is presented for determining the presence or absence of a left-to-right circulatory shunt in patients with congenital heart disease. In the course of right heart catheterization, patients inhaled a mixture of krypton^{85} and air for 30 seconds, as blood samples were drawn simultaneously from the pulmonary artery and from a systemic artery. It was found that when the radioactivity of pulmonary arterial blood was more than 20 per cent of the systemic arterial level, the diagnosis of a shunt could be made; when less than 10 per cent, the absence of a shunt was confirmed, and tests between 10 and 20 per cent were considered inconclusive and were repeated. The blood samples were analyzed with a gas flow counter and scaler, and the results were available within five minutes. When the pulmonary artery test was positive, the test was repeated in the right ventricle and right atrium to localize the shunt. The advantages of the Kr^{85} test over the method employing blood oxygen differences was demonstrated in 52 patients studied by both methods. There were six diagnostic errors with the oxygen method and none with Kr^{85}. (auth)

14583 A/CONF.15/P/869

Roswell Park Memorial Inst., Buffalo.

RADIOACTIVE ANTI-TUMOR ANTIBODIES. David Pressman, Eugene D. Day, and Monte Blau. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

When antibodies prepared against tumors are labelled with radioactive isotopes, it is possible to determine whether such antibodies localize specifically in the tumor. There is, moreover, the possibility that radiolabelled antibodies can be used diagnostically to determine the location of tumors and their metastases and perhaps therapeutically to carry physiological amounts of radioactivity to the tumor. Preparations from antitumor serums localized in the tumor only slightly more than did control serum preparations. Tumor localizing antibodies were contaminated with antibodies capable of localizing elsewhere in normal tissues. Methods have now been developed which permit specific purification of radioiodinated anti-tumor antibodies so that as much as 36% of the injected material has been observed to localize in the Murphy lymphosarcoma of rats (the tumor most intensively studied) and cross-localizing activity has been largely minimized. These two improvements were accomplished by specific purification procedures in which the tumor localizing antibodies were concentrated by absorption on ascites tumor cells and subsequent elution, while cross-localizing antibodies were removed by absorption with normal tissue. Previous work showed that radioactivity from antitumor or control preparations did not localize uniformly throughout the tumor. Methods have now been developed by paired label techniques in which antiserum preparations labelled with a certain isotope and control preparation tagged with the same chemical label but containing another isotope are injected simultaneously to permit determination of just how much control material and how much antibody has localized in any particular part of the tumor. The use of radiolabelled antibodies as a diagnostic tool to determine the location of tumors has now been demonstrated in the case of animal tumors where the tumor was located by radioscanning methods. (auth)

14584 A/CONF.15/P/870

California. Univ., Los Angeles. Atomic Energy Project; California. Univ., Los Angeles. School of Medicine; Veterans Administration Center, Los Angeles; and Los Angeles County Harbor General Hospital, Torrance, Calif.

NEW RADIODIAGNOSTIC TECHNIQUES FOR INVESTIGATING PARENCHYMAL AND OBSTRUCTIVE LIVER AND KIDNEY DISEASE. Pathophysiological Studies in Animals and Clinical Applications. G. V. Taplin, O. M. Meredith, Jr., H. Kade, C. C. Winter, and D. Johnson, 31p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Recent advances in the development and clinical evaluation of external tracer techniques for measuring multiple functions of the liver and kidneys with I^{131} labeled Rose Bengal I^{131} and Diodrast are described. The Rose Bengal I^{131} blood clearance-liver uptake tracer test provides reliable indices of polygonal cell function and liver vascular capacity. The sensitivity of the tracer test is increased by the simultaneous injection of bromsulphalein in stress doses of 3-5 mg/kg. Normal tracer and stress test findings indicate the absence of significant liver pathology. A dual Rose Bengal I^{131} Hepatogram, a multipurpose tracer procedure, is useful in the differential diagnosis of medical versus surgical jaundice. When the Hepatogram is used repeatedly in patients with

hepatobiliary diseases results correlate well with the clinical findings and indicate changes in the underlying pathophysiological disturbances more quickly and accurately than do indirect biochemical liver tests. The Diodrast I^{131} Renogram developed as a logical corollary to the Hepatogram has been evaluated through extensive clinical investigations in more than 800 patients with a variety of urological diseases. Although the sensitivity for measuring tubular cell function is no greater than most of the other dye excretion tests, its advantages as a simple nontraumatic method for measuring multiple functions of each kidney separately make it a valuable procedure in the practice of urology. Furthermore, the renogram has been demonstrated to be a reliable rapid screening test for hypertensive patients suspected of having unilateral renal lesions. It provides a simple diagnostic tool which is needed to extend the investigation of renal hypertension into the field of pediatrics. Most hypertensive patients having normal renogram findings may be spared the discomfort, time, and expense of extensive urological investigations, which are otherwise considered essential. (auth)

14585 A/CONF.15/P/871

Argonne Cancer Research Hospital, Chicago. and Chicago. Univ.

THE DISTRIBUTION OF INTRAPERITONEAL RADIO COLLOIDS. Paul V. Harper and Katherine A. Lathrop. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The frequent use of colloidal Au^{198}, Y^{90}, and $CrP^{32}O_3$ for the treatment of tumor ascites and destruction of tumor cells seeded at operation has led us to investigate in more detail the distribution of such substances in the peritoneal cavity. Following intraperitoneal injection of $Y^{90}Cl_3$ in rats, the viscera and anterior abdominal wall were removed after various lengths of time, sealed in polyethylene envelopes, and placed on photographic film to make radioautographs. The observed distribution was very similar to that observed with India ink, radioactivity first appearing in the mesenteric lymph nodes and omentum and later in the liver and spleen. Factors influencing this distribution were found to be local peritonitis, this produced a marked localization in the inflamed area; protein conjugation, YCl_3 injected in the serum left the peritoneal cavity rapidly; carrier, migration of the yttrium to the liver and spleen was markedly retarded by increasing the inert yttrium injected with the radioisotope; and gravitational effect, injection of a large volume of fluid resulted in localization in dependent areas. (auth)

14586 A/CONF.15/P/876

Veterans Administration Center, Los Angeles.

THE DIFFERENTIAL DIAGNOSIS OF JAUNDICE WITH RADIOACTIVE ROSE BENGAL. Robert A. Nordyke and William H. Blahd. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A direct method is presented for determining the presence of extra-hepatic biliary tract obstruction, using intravenously administered radioactive rose bengal followed by external scintillation monitoring. (auth)

14587 A/CONF.15/P/877

Harvard Univ., Boston. Medical School and Massachusetts. General Hospital, Boston.

A COMPARISON OF THE DISTRIBUTION OF MAGNESIUM-28 WITH THAT OF POTASSIUM-42 AND CALCIUM-45. Benjamin A. Barnes and Gordon L. Brownell. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A technique of studying the simultaneous tissue distribution of magnesium-28, calcium-45, and potassium-42 is presented to clarify the physiologic role of magnesium. The rates of transfer of magnesium and calcium from the serum were found to be approximately equal. The minimum, virtual mass of magnesium, with which the isotope had exchanged at 18 hours, was found to be only a small fraction of the stable, soft tissue magnesium. Direct measurements on skeletal muscle confirmed this interpretation. Intracellular magnesium, unlike potassium, is not available for prompt exchange. (auth)

14588 A/CONF.15/P/879

California. Univ., Los Angeles. School of Medicine, and California. Univ., Los Angeles. Atomic Energy Project.

METHODS FOR THE STUDY OF CEREBRAL BLOOD FLOW KINETICS WITH GAMMA-EMITTING RADIOISOTOPES. Paul Crandall and Benedict Cassen. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Good estimates of total cerebral blood flow can be obtained by a technique somewhat analogous to that of externally estimating cardiac output volume rate. Radioiodinated human serum albumin is pulse-injected into a carotid artery. The pulse of activity is recorded as it passes through the torcula Herophili, a venous sinus that normally drains a large fraction of the total cerebral blood flow. The sinus is near the surface and is easily locatable. A scintillation crystal placed close to the sinus and suitably collimated responds nicely to the pulse of activity. The numerical value of flow can be determined only if the equilibrium value of the activity in the sinus can be determined. This is not possible directly. However, the sinus is anatomically constant enough so that measurements can be made on phantom models containing known concentrations of activity. As the final blood concentration can be readily measured on the patient, the phantom studies enable calibration of the absolute blood flow. The pulse records also enable transit times and pathological irregularities of these times to be determined. (auth)

14589 A/CONF.15/P/880

Veterans Administration Hospital, St. Louis; Saint Louis Univ. School of Medicine; and Washington Univ., St. Louis. School of Medicine.

CORONARY BLOOD FLOW DETERMINATIONS WITH RADIOACTIVE RUBIDIUM. R. E. Mack, D. D. Nolting, M. Kirsch, E. Luethy, J. Duttachoundhury, C. E. Hogancamp, and R. J. Bing. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The adaptation of the Fick Principle to determinations of coronary blood flow from myocardial Rb^{86} uptake in dogs was studied. This method was found to give results comparable to simultaneously determined coronary flows by the established nitrous oxide method. Since the mean myocardial extraction rate of 47% was shown to be independent of arterial Rb^{86} concentration, determination of coronary blood flow without coronary minus catheterization is possible by the rubidium method. (auth)

14590 A/CONF.15/P/896

California. Univ., Berkeley. Donner Lab.

DNA SYNTHESIS IN IRRADIATED ANIMALS. Lola S. Kelly. 9p. (UCRL-3995). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experiments carried out during the past few years strongly suggest that the generally observed inhibition of desoxyribose nucleic acid (DNA) synthesis after radiation is a secondary effect principally due to changes in cell populations. Furthermore, the mitotic delay after radiation must be due to some radiosensitive process independent of any possible effect on DNA synthesis. (auth)

14591 A/CONF.15/P/910

Argonne National Lab., Lemont, Ill.

STRUCTURAL CHANGES IN HUMAN BONE CONTAINING Ra^{226}. R. E. Rowland, Jenifer Jowsey, and John H. Marshall. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Bones from 15 individuals who carried Ra^{226} for many years have been examined by microradiographic and autoradiographic techniques. Some of these subjects were radium dial painters, who may have had mesothorium in addition to their measured radium burden. Others were treated with radium therapeutically, of which three were given multiple injections of pure Ra^{226} in known quantities. The latter group provide what we believe to be the only source of long term data concerning a human skeletal burden of radium injected under controlled conditions. Microradiographs of thin sections from these bones show many characteristic changes in the mineral structure: most prominent of these is the occlusion of the Haversian canal by material of high mineral density. A considerable reduction of blood flow through cortical bone must have resulted in some of these cases as a result of the large number of these occlusions. Also in evidence are larger regions of abnormally high mineral density, and instances of bizzare types of resorption. The density of the inorganic components of these damaged bones has been measured by quantitative microradiography, and compared with densities found in normal bones of comparable ages. The inorganic composition of bone mineral, in terms of calcium and phosphorous, of these microscopic regions of abnormal density has been determined with mono-energetic x-rays. Recent studies on the radon retention of bone sections have placed the dosimetry of radium containing bone on a solid footing, for the relationship between the alpha tracks observed in an autoradiographic emulsion and those which occurred in living bone has been assessed; hence quantitative autoradiography of these bone sections yields the dose to microscopic portions of the bone specimen. For the three cases in which the quantity of Ra^{226} injected is known, it is possible to reconstruct the dosage to parts of the bone throughout the lifetime of the individual; moreover, the specific activity of existing deposits of radium, compared to the specific activity of the blood during the time in which these systems were laid down, gives a measure of the magnitude of the loss of Ra^{226} by processes other than direct resorption. (auth)

14592 A/CONF.15/P/913

Brookhaven National Lab., Upton, N. Y.; Brown Univ., Providence; and National Institutes of Health, Bethesda, Md.

CELL RENEWAL, MATURATION AND DECAY IN THE GASTRO-INTESTINAL EPITHELIA OF NORMAL AND IRRADIATED ANIMALS. H. Quastler, F. G. Sherman, G. Brecher, and E. P. Cronkite. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A method is described which yields much new information on the details of kinetics of steady-state cell systems in normal and irradiated animals. It is based on high-resolution autoradiography following administration of thymidine labeled with tritium. A fraction of the tritium so delivered is solidly anchored in desoxyribonucleic acid (DNA) within a short time, and the remainder transformed into products which are washed out spontaneously or in the course of making the histological preparation. Accordingly, only those cells remain labeled which have synthesized DNA at the time of labeling. Because of the short range of tritium beta rays, each individual labeled nucleus can be identified with certainty on the autoradiograph. With the help of closely spaced sacrifice series, it was possible to reconstruct accurately the timing of mitotic cycles and to study variations in the lengths of interphases following divisions. Also, subsequent movements and differentiation of labeled cells have been accurately timed. These studies yield better understanding of some radiation responses and of the normal organization and kinetics of steady-state cell systems. (auth)

14593 A/CONF.15/P/1029

General Elextric Co. Hanford Atomic Products Operation, Richland, Wash.

RADIOSTRONTIUM–CALCIUM RELATIONS IN PLANTS AND ANIMALS. H. A. Kornberg. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In laboratory experiments the uptake in plants of Strontium-90 was measured as a function of calcium in the root environment. In general, the uptake of Sr^{90} was not found to decrease as a result of the calcium present. When rats were intraperitoneally injected or fed in single doses mixtures of Sr^{90} and calcium, the deposition of Sr^{90} on the skeleton was not found to be affected by the presence of calcium in the administered dose. Groups of rats which were maintained on diets containing several levels of calcium along with Ca^{45} and Sr^{90} were found to deposit less Sr^{90} and Ca^{45} on their skeletons as the calcium in the diet was increased. However, the decrease of Sr^{90} deposition with increase in dietary calcium was less than that which would have occurred if the strontium had deposited in inverse proportion to the calcium in the diet. The data also showed that beyond 0.5% of dietary calcium there was no further decrease of Sr^{90} deposition with increase of calcium. Similar observations were made with lambs that were fed Sr^{90} and calcium gluconate in milk. The gluconate ion was found to account for a significant amount of the decreased Sr^{90} deposition observed. These experimental observations point to the need for measuring Sr^{90} contamination in absolute units and tend to support theoretical considerations of the effect of isotopic dilution. The movement and deposition of substances can occur by only four processes: flow, diffusion, adsorption, and chemical reaction. Each of these processes may be separately considered to determine the effect of the addition of one isotope on the movement or deposition of another isotope. For the processes of flow and simple diffusion, isotopic dilution is without effect. For the processes of adsorption and chemical reaction, isotopic dilution will be effective only under the condition that some acceptor material upon which the element deposits approaches saturation. Even under this condition the effect of one isotope on another need

not be a linear inverse relationship. Experimental data involving radioactive and non-radioactive isotopes other than radiostrontium and calcium which also support these hypotheses are presented. (auth)

14594 A/CONF.15/P/1037

Brookhaven National Lab., Upton, N. Y. and Yeshiva Univ., New York. Albert Einstein Coll. of Medicine.

CARBON-14 IN THE STUDY OF METABOLIC PROCESSES IN MAN. W. W. Shreeve, L. I. Gidez, H. A. Eder, A. R. Hennes, and D. D. Van Slyke. 12p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Applications and techniques for using C^{13} and C^{14} in metabolism studies are reviewed. The specific examples of studies of carbohydrate metabolism using C^{14}-glucose and C^{14}-acetic acid, and of lipid metabolism using C^{14}-acetic acid, and of cholesterol metabolism using C^{14}-mevalonic acid are discussed. (T.R.H.)

14595 A/CONF.15/P/1040

Colorado. Univ., Denver. School of Medicine.

Mg^{28} TRACER STUDIES OF MAGNESIUM METABOLISM IN ANIMALS AND HUMAN BEINGS. Jerry K. Aikawa. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Magnesium-28 was used to study different chemical methods for the separation of magnesium from calcium in biologic material. The molybdivanate colorimetric method was used. Extracellular clearance, urinary excretion and tissue distribution of Mg^{28} was studied initially in rabbits. The relationship between change in magnesium content and body weight during starvation was also studied in rabbits. The oral administration to human beings of a tracer dose of this isotope as $MgSO_4$ or $MgCl_2$ resulted in the urinary excretion of less than 6% of the radioactivity within 24 hours; most of the Mg^{28} was recovered from the stool. Following the intravenous infusion of 50 microcuries of Mg^{28} in 5 to 10 milliequivalents of Mg, radioactivity concentration in the plasma decreased rapidly during the initial three hours and slowly exponentially between 14 to 27 hours. The specific activities of plasma and urine diminished gradually during the latter phase. Urinary excretion of 20 to 25% of the radioactivity occurred within the first 24 hours and was minimal thereafter. Facal excretion was less than 2% of the infused dose. The exchangeable magnesium values calculated from the specific activities of plasma and urine were considerably lower than the estimated body magnesium content. Surface monitoring over the body of human subjects given the intravenous infusions of Mg^{28} revealed maximal concentration of radioactivity over the liver within the first three hours. There was minimal concentration of radioactivity over bone and muscle masses. (auth)

14596 A/CONF.15/P/1057

Massachusetts Inst. of Tech., Cambridge. Radioactivity Center.; Peter Bent Brigham Hospital. Kidney Lab., Boston.; and Massachusetts. General Hospital. Huntington Memorial Labs., Boston.

A STUDY OF THE DYNAMICS OF STRONTIUM AND CALCIUM METABOLISM AND RADIOELEMENT REMOVAL. W. B. Looney, C. J. Maletskos, Marie Helmick, John Reardan, Jonathan Cohen, John Buchanan, F. I. Visalli, John Merrill, and Warren Guild. 13p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An estimate of the maximum rate of calcium mobilization has been obtained by circulating the blood of dogs either through an ion-exchange column or artificial kidney. The utilization of two radioisotopes of strontium and one radioisotope of calcium gave a means for comparing strontium and calcium metabolism under non-equilibrium conditions. The methods described are also of theoretical value in decreasing exposure of the kidney to nephrotoxic elements. (auth)

14597 A/CONF.15/P/1058

Department of Agriculture. Mineral Nutrition Lab., Beltsville, Md.

THE FUNCTION OF OXIDATIVE METABOLISM IN THE PASSAGE OF IONS INTO PLANTS. Cal E. Hagen and Sterling B. Hendricks. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The cellular accumulation of phosphate as followed with phosphorus-32 tracer is shown to take place through sites coupled with oxidative phosphorylation in respiration. (auth)

14598 A/CONF.15/P/1545

California. Univ., Berkeley. Donner Lab.

ISOTOPIC MEASUREMENTS OF THE LIFE SPAN OF HUMAN ERYTHROCYTES, LEUKOCYTES, AND PLATELETS. Myron Pollycove. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The life span of the erythrocyte in man was found to be approximately 105 to 130 days by tracer techniques involving in vivo labeling with Fe^{59}, Fe^{55}, N^{15}-glycine, C^{14}-glycine, P^{32}-diisopropylfluorophosphonate (DFP^{32}) and in vitro Cr^{51}. Leukocyte life span values from 8 to 17 days were obtained by in vivo labeling with P^{32}-DNA and S^{35}-l-cystine, and DFP^{32}. Mean platelet life span of 10 or 11 days was established by in vivo labeling with DFP^{32} and in vitro Cr^{51}. (T.R.H.)

14599 A/CONF.15/P/1898

California. Univ., Berkeley. Donner Lab. and California. Univ., Berkeley. Radiation Lab.

MAPPING THE DISTRIBUTION OF GAMMA-RAY-EMITTING ISOTOPES WITH THE SCINTILLATION CAMERA. Hal O. Anger. 8p. (UCRL-3992). $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The design and use of a scintillation camera for mapping the distribution of γ-ray-emitting isotopes in the thyroid gland and other tissues are discussed. (C.H.)

14600 A/CONF.15/P/1899

California. Univ., Berkeley. Donner Lab. and California. Univ., Berkeley. Donner Pavilion.

BIOLOGICAL AND CHEMICAL CHARACTERISTICS OF URINARY ERYTHROPOIETIN. D. C. Van Dyke, J. F. Garcia, and J. H. Lawrence. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Of 25 patients with various hematologic and other disorders who were studied by the Fe^{59}-incorporation assay, two showed high levels of erythropoietic activity both in plasma and urine, two showed high levels in the plasma but no activity above normal in the urine, and 1 showed high activity in the urine but no increase in activity above normal in the plasma. The significance of the elevated urinary activity was further demonstrated by injecting extracts of the urine from those patients who showed high erythropoietic activity by the Fe^{59} assay into normal rats for 14 days. The urine of three of the four patients tested in this way produced a

polycythemia that exceeded that produced by exposure of normal rats to a simulated altitude of 15,000 ft for the same period of time. It is suggested that our knowledge of the mechanisms responsible for an elevated erythropoietin in the body fluids may be advanced more quickly by the simultaneous assay of both urine and plasma of patients with various hematological disorders and by evaluating the significance of the Fe^{59} red-cell-incorporation assay by determining whether those samples that appear to be active are capable of producing a polycythemia when injected into normal rats. Erythropoietically active material prepared from the urine of one case of aplastic anemia and one case of paroxysmal nocturnal hemoglobinuria was effective in producing a polycythemia in normal rats, mice, rabbits, and one monkey when given daily for 14 days. The fact that the urinary erythropoietin is neither precipitated nor inactivated on boiling is not completely destroyed by prolonged digestion with trypsin, is precipitated at pH 3, and is present in that part of the residue remaining after ultrafiltration that contains a large amount of carbohydrate suggests that the urinary erythropoietin may be a mucoprotein. Similar evidence, along with the demonstration that plasma-erythropoietin activity is soluble in 5% perchloric acid, has suggested that the plasma erythropoietin is also a mucoprotein. Evidence is presented, however, that indicates some differences in chemical properties of plasma and urinary erythropoietins. (auth)

14601 A/CONF.15/P/1901

Western Reserve Univ., Cleveland.

ON VISUALIZATION OF SOME INTERNAL STRUCTURES UTILIZING RADIOISOTOPES. Hymer L. Friedell, William J. MacIntyre, and Abbas M. Rejali. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Radiation arising from selectively deposited radioelements in tissues may be used to record the spatial disposition of these elements so as to reflect the configuration of the organ structure. To accomplish this, an automatic scanning device was utilized. The counter impulses were fed into recording systems of two types, an activated stylus recording on electrosensitive paper, and an oscilloscopic method whereby various levels of activity were recorded by modulation of the beam. A photographic record was then obtained. In order to accentuate the modest differences in radioactivity, a cut-off circuit was introduced between the scaler and the recording system. This was arbitrarily set so that the background and non-contributory radiation could be eliminated. In the oscilloscopic system, accentuation of these differences was obtained also by increasing the intensity of the oscilloscopic beam by effectively utilizing the film response. Recently, because of difficulties encountered in arbitrarily establishing the proper cut-off level, an additional modification has been introduced. Impulses from the counting rate meter are recorded on an electromagnetic tape. This electromagnetic record, after being synchronized with the scanning movement of the detector, is fed back into the counting rate meter and recorded by either of the two methods noted above. This has the very important advantage of permitting multiple records at numerous cut-off levels and optimum visualization may be obtained. Application of this method has been used primarily for visualizing the structure of the liver, and the general configuration and position of various blood pools. The radiocompounds used for this study included tagged rose bengal (I^{131}), tagged tetraiodophenolphthalein (I^{131}) and colloidal Au^{198}. Tagged serum albumin (I^{131}) was used for the vascular studies. (auth)

14602 A/CONF.15/P/1996

Kansas. Univ., Lawrence.

THE METABOLISM OF Sr 90 AND Y 90 AND THE INFLUENCE OF LACTATION ON RETENTION. Frank E. Hoecker and Edward I. Shaw. 15p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Detailed studies of the metabolic history of strontium-90 and yttrium-90 in terms of retention as influenced by gestation and lactation are reported for rats which received intraperitoneal injections either 52 days before parturition or within 24 hours after parturition. Retention periods ranging from 7 minutes to 100 days are covered for 11 body compartments including soft tissue, bones (excluding femurs), femurs, blood, mammary glands, kidneys, liver, muscle, testis, spleen, and litters. Data for $Sr^{90}-Y^{90}$ in equilibrium are based on crystal detection of bremsstrahlung in which energy dependence errors are eliminated by spectrometric analysis and geometrical errors are avoided by digesting or homogenizing tissues. Y^{90} and Sr^{90} are studied separately by half-life measurements based on beta-particle detection. When compared with unbred controls the retention of Sr^{90} in the bones of rats injected 52 days prepartum is not significantly influenced by lactation, but that of animals injected at parturition is markedly affected. When the % of dose retained by the latter group is plotted versus time after injection, the depletion of calcium in the bones during gestation is reflected by increased Sr^{90} uptake for the first 5 hours after injection at which time the uptake in both the controls and in the postpartum group reaches a minimum of 42 percent. From this value the retention in both decreases with time although lactation in the postpartum group is responsible for a much greater rate of elimination of Sr^{90} during the first 18 days of lactation which results in a retention of only 5% of the dose at 100 days as compared with a retention of approximately 15% in the controls at that time. Data on soft tissue retention show approximately 80% in all groups at 7 minutes after injection. Greater avidity of the bones is again shown by a slightly lower soft tissue retention in the postpartum group although this lower retention vanishes at 7 hours after injection, after which time the soft tissue content increases from 25% to reach a maximum of 37% in 24 hours. This increase in soft tissue retention coincides with the onset of lactation and reflects mobilization of calcium (and hence Sr^{90}) from the bones. It also coincides with the time of decreased bone retention referred to above. Sr^{90} concentration in the blood decreases by a factor of 7 during a period of 2 hours following injection. In the control group the blood content is essentially zero within 24 hours, while in the lactating group the Sr^{90} concentration reaches a minimum at 24 hours but undergoes an increase which coincides with the increase in soft tissue content resulting from the onset of lactation. (auth)

14603 A/CONF.15/P/2003

Rochester, N. Y. Univ. School of Medicine and Dentistry.

THE MECHANISM OF TRANSPORT OF BIVALENT CATIONS INTO THE YEAST CELL. Aser Rothstein. 15p. $0.50(OTS).

Prepared for the Second U. N. International Confer-

ence on the Peaceful Uses of Atomic Energy, 1958.

Isotope techniques are particularly useful in the study of exchanges of cations across cell membranes. In the case of bivalent cations, useful isotopes are available for a number of physiologically important elements such as Ca, Sr, Mn, Zn, and Co, but not for Mg. Fortunately Mn and Mg behave similarly. Previous studies with bivalent cations indicate that two basic phenomena are involved; a reversible binding of the cations by anionic groups of the cell surface, and an essentially irreversible active-transport of the cations into the interior of the cell. The latter process requires energy derived from glycolysis, is related to the absorption of phosphate and potassium, and is relatively specific for Mg and Mn as compared with Ca and Sr. If the term "carrier" is applied to the membrane substances involved in the active transport process, then the evidence suggests that the "carrier" for Mg and Mn is a phosphorylated product formed from extracellular phosphate. Thus, starved cells possess no capacity to transport the bivalent cations, nor does such a capacity appear during the active turnover of intracellular phosphate associated with metabolism. However, during the active transport of extracellular inorganic phosphate into the cell, the capacity to absorb Mg and Mn is acquired; a capacity which is retained for many hours in quiescent cells, but which disappears rather rapidly in glycolysing cells. The chemical nature of the cation-carrier is not specifically known. The conclusion that a phosphate compound is involved is based on the following facts: synthesis occurs only during phosphate absorption; breakdown is rapid during glycolysis; inhibition is observed with arsenate, a substance closely related to phosphate. The carrier is not identifiable with any of the known phosphate compounds of the cell. It is formed in small amounts from only a fraction of the absorbed phosphate, and therefore must function in a cyclic manner with a rapid turnover. The specificity pattern of the absorption process suggests that a protein is also involved. Both transport processes, that of phosphate and that of the bivalent cations, are membrane phenomena that are essentially irreversible, that is, no exchanges occur across the membrane. Both processes are coupled to a specific mode of metabolism, glycolysis, presumably at the glyceraldehyde-3-phosphate dehydrogenase reaction. The coupling is neither stoichiometric nor obligatory. The molecular mechanism is not known in either case, and further analysis of the situation is limited by lack of information concerning the intimate structure of the cell membrane. (auth)

Waste Disposal

14604 A/CONF.15/P/1834

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

METEOROLOGICAL FACTORS IN THE APPRAISAL AND CONTROL OF ACUTE EXPOSURES TO STACK EFFLUENTS. James J. Fuquay. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A method is developed for use in the analysis and meteorological control of atmospheric pollution problems resulting from gaseous emissions from tall stacks. Special attention is given to the dilution of the gas within the stack due to the addition of excess air. Control parameters are developed for cases in which short periods of high concentration are important, as contrasted to long-period average concentrations. Application of the method is demonstrated with a sample calculation. (auth)

CHEMISTRY

14605 A/CONF.15/P/457

Argonne National Lab., Lemont, Ill.

FLUID METAL FUELS: UO_2–NaK SLURRY. B. M. Abraham, H. E. Flotow, and R. D. Carlson. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Investigations of UO_2-NaK suspensions were initiated as part of a program to develop a fluid fuel suitable for a fast reactor. Most of this work was done with suspensions containing 5 volume % (40 wt. %) UO_2 in NaK, a concentration suitable only for thermal reactors, because the necessary basic information can be obtained more readily with dilute slurries. As normally prepared, UO_2 contains more than the stoichiometric amount of oxygen. It was found that NaK will readily wet UO_{2+x}, a necessary condition to effect suspension, if x is no greater than 0.01; if x is greater than 0.01 wetting occurs after the excess oxygen has reacted to produce Na_2O. The minimum contact angle observed for sessile drops of NaK on UO_2 plaques was 22°. This result implies that the slurries will be flocculated. A slurry of 5 volume % UO_2 could be maintained uniform throughout the loop volume at a minimum flow rate of 2 ft./sec (61 cm/sec) at all temperatures up to 500°C. Above 500°C, the slurry could no longer be maintained uniform at flow rates of 8 ft/sec (244 cm/sec). As soon as the temperature was reduced to 480 to 490°C the slurry became uniform in a matter of seconds. There was no marked change in the particle size of the UO_2 after circulating for 400 hours at the high temperatures. Metallographic examination of loop sections and chemical analyses of the slurry components failed to show evidence for corrosion or erosion. Some preliminary work with a 15 volume % slurry (65 weight % UO_2), which begins to approach the concentration required for a fast reactor, showed that the slurry was sufficiently fluid to be circulated in the apparatus and it appeared to be uniform. Information obtained to date (in the absence of radiation) on the rheology, the corrosion and the erosion of the slurries indicates that dilute suspensions of UO_2 in NaK offer promise as thermal reactor fuels; more information is needed on concentrated slurries before a definite statement can be made on applicability to fast reactors. (auth)

14606 A/CONF.15/P/611

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

RADIOLYTIC AND PYROLYTIC DECOMPOSITION OF ORGANIC REACTOR COOLANTS. D. R. de Halas. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Investigations were conducted on the kinetics of organic reactor coolant decomposition. The experiments consisted of low temperature irradiations of the coolants in a dynamic system. Material that had undergone essentially no pyrolytic damage, but had been considerably decomposed by radiolytic damage was obtained in this manner. The purely radiolytic damage was found to follow a first order rate law. The presence of tar in solution had no effect on the decomposition rate other than to

reduce the amount of pure coolant in the flux. Hence a coolant stream containing 50% tar decomposes at 50% of the rate of pure coolant. The radiolytic rate constants for several candidate materials are tabulated. Studies were also conducted on the pure pyrolytic damage rates of organic coolants. Again the decomposition was found to follow a 1st order law. The rate constants were determined as a function of temperature for several compounds. By using the data on the pyrolytic rates in conjunction with the pure radiolytic rates, the combined form of the rate law expression can be used to determine the maximum utilizable temperature for various organic coolants. In practice this maximum utilizable temperature can be approximately determined by about three laboratory measurements to measure the purely pyrolytic damage rates, and one or two in-pile irradiations made at a low temperature. (auth)

14607 A/CONF.15/P/664
Los Alamos Scientific Lab., N. Mex.
PREPARATION OF FOILS. J. G. Povelites. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The details of apparatus and techniques used for the preparation of foils from a wide variety of materials are presented. The average foil thickness is determined by weighing, counting, fission weighing, or by calorimetric analysis. Uniformity is determined by counting or weighing small areas or by exposure to a nuclear emulsion. Impurities are determined by chemical analyses. The principal methods of preparation are electrodeposition, painting from solution, vacuum deposition, electrostatic spraying, and electrophoresis. Electrodeposition is used for the preparation of films of a few $\mu g/cm^2$; uniformity and deposition efficiency are good. The painting method is used where uniformity is not important; however, a uniformity of 10% may be be attained. The vacuum evaporation method may be adapted to many metals and compounds and covers the thickness range from a few $\mu g/cm^2$ to several mg/cm^2, producing the most uniform deposits. Electrostatic spraying is of limited use. Electrophoresis is used inside cylinders and on irregular surfaces where tight adherence is not essential. (J.R.D.)

14608 A/CONF.15/P/715
Argonne National Lab., Lemont, Ill.
HIGH TEMPERATURE THERMODYNAMIC PROPERTIES OF REACTOR MATERIALS. R. J. Ackermann and R. J. Thorn. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

High-temperature thermodynamic properties of reactor materials are important to chemical engineers, ceramists, metallurgists, and reactor engineers in developing pyrometallurgical processing procedures, fabricating fuel assemblies, and designing high temperature reactors. A critical evaluation and discussion is to be presented so that reliable free energies and phase diagrams if possible are available to enable one to predict the behavior of various chemical systems which may be proposed for use at temperatures above 1000°C. One aspect which will become increasingly more important when systems are considered for high temperatures is the production of gases from condensed phase reactions. The behavior in this respect of two classes of compounds, oxides and carbides, of aluminum, beryllium, hafnium, magnesium, plutonium, tantalum, tungsten, thorium, uranium, and zirconium is examined. The oxides are of interest because of their high stabilities and the carbides because of their high conductivities and because of the desirable nuclear properties of carbon. (auth)

14609 A/CONF.15/P/722
Brookhaven National Lab., Upton, N. Y.
TEMPERATURE INDEPENDENT ISOTOPE EFFECTS IN CHEMICAL EXCHANGE EQUILIBRIA INVOLVING LINEAR MOLECULES. Jacob Bigeleisen. 11p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The temperature independent factor of the equilibrium constant of an isotopic exchange reaction arises from the classical contribution to the quantum mechanical partition function. It consists of a symmetry number factor and a ratio of vibrational frequencies of the isotopic molecules. Only those vibrational frequencies whose Boltzmann arguments, $hc\omega/kT$, are greater than 2π can contribute to the temperature independent factor. For exchange reactions occurring above room temperature only stretching frequencies are to be included in the ratio of vibrational frequencies. In a linear molecule containing n atoms, the 3n-5 vibrations can be divided into n-1 stretching vibrations and n-2 doubly degenerate vibrations. The n-1 stretching vibrations are in the same symmetry class, Σ^+, with the translation of the whole molecule along the direction of the internuclear axis. It is shown that the product rule for this symmetry class suffices to reduce the temperature independent factor in either the equilibrium constant, partition function ratio, or free energy function to a simple function of the symmetry numbers, and atomic and molecular weights. The temperature independent contribution to the equilibrium constant for an isotopic exchange reaction between linear molecules is a function of the symmetry numbers and molecular weights alone. Applications of this theorem are made to the calculation of equilibrium constants, to systems involving isotopic isomers, and to deviations from the rule of the geometric mean. A simple physical interpretation to the origin and evaluation of the temperature independent factor can be given in terms of the entropy associated with the translation of a particle in a box. (auth)

14610 A/CONF.15/P/753
Saint Procopius Coll., Lisle, Ill.; Argonne National Lab., Lemont, Ill.; and Columbia Univ., New York.
CONDUCTING PLASTIC EQUIVALENT TO TISSUE, AIR, AND POLYSTYRENE. Francis R. Shonka, John E. Rose, and Gioacchino Failla. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A series of conducting plastic resins has been developed which make possible the direct measurement of absorbed dose in rads for photons and neutrons in muscle, bone, and polystyrene; rads for photons in muscle (insensitive to neutrons); and roentgens. The components chosen for tissue, air, and polystyrene equivalent materials should result in a conducting blend with the best possible mechanical properties and having the same absorption for photons and neutrons as the material simulated. This means that for equal numbers of electrons in simulated and equivalent materials, the number of hydrogen and nitrogen atoms in the equivalent must be equal to those contained in the simulated material or to zero, depending on whether the equivalent material is to be sensitive or insensitive to neutrons; and the sum of the photoelectric absorption cross section for soft x rays must be equal for both. Commercial

plastics are blended with suitable additives producing compounds which achieve the desired atomic composition and radiation response, and which can be readily produced for injection and compression moulding. So that the same photoelectric absorption coefficients for low energy x rays will result, the oxygen or nitrogen deficiencies caused by high carbon content must be balanced. This is done by substituting elements of higher atomic number; specifically, fluorine, silicon, or calcium. Since commercial equipment for intensive mixing in small batches is unavailable, a mixing system consisting of concentric screws and cylinders with but one rotating element has been designed to achieve the necessary high degree of turbulence and shear. Mills of up to 375 gram capacity are operating successfully. The additives used in compounding the conducting plastic resins are uniformly dispersed during mixing and are of a particle size less than one tenth of the range of the photoelectrons produced in them by soft x rays. These thermoplastics absorb neutrons and photons over a wide range of energies in nearly the same way as muscle, bone, air, and polystyrene, and therefore have important applications. One of these applications is for ionization chambers. Here, when the gas volume is large, it is necessary to use a gas mixture equivalent to the wall. Furthermore, if chambers are to read exposure dose, compensation for attenuation and degradation of the primary beam in the wall must be considered. Experiments are presently in progress to study whether the necessity for having equivalence of wall and gas can be eliminated by suitable choice of the geometry of the electrodes and adjustment in the composition of the wall. (auth)

14611 A/CONF.15/P/826
Continental Can Co., Inc., Chicago.
MODIFICATION OF POLYMERS BY IONIZING RADIATION: VULCANIZATION AND GRAFT COPOLYMER FORMATION. Robert B. Mesrobian. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The preparation, properties, and application of two classes of graft copolymers obtained with the aid of gamma-rays are described; graft copolymers of polyethylene containing styrene which are converted to permeaselective ion exchange membranes having important usage for the removal of salt from water by the method of multiple chamber membrane electrodialysis and the simultaneous grafting and vulcanization of natural rubber with several vinyl monomers. The latter method not only serves to minimize the dose required to effect gelation of network chains but also enables the preparation of vulcanizates having a broad range of mechanical and chemical properties. (auth)

14612 A/CONF.15/P/934
Princeton Univ., N. J.
THE USE OF ISOTOPES AND RADIATION IN THE STUDY OF HETEROGENEOUS CATALYSIS. John Turkevich. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A review is given of the contributions made to the study of the mechanism of heterogeneous catalysis using radioactive and stable isotopes. Further, a review is presented on the effect of high energy radiation on catalytic activity. In addition, results on the use of deuterium to characterize the catalytic activity of carbons before, during, and after radiation damage are presented. These results are compared with those obtained by thermal treatment. The subsidiary techniques of ortho-para hydrogen conversion and electron spin resonance are used to explain the nature of catalytic activity. (auth)

14613 A/CONF.15/P/940
Argonne National Lab., Lemont, Ill.
THE CHEMISTRY OF FUSED SALTS. Dieter M. Gruen, Sherman Fried, Peter Graf, and Robert L. McBeth. 26p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Recent work done on the chemistry of fused salts is reviewed, and the directions in which further information is being developed is indicated. Oxidation states of many actinide and rare earth ions dissolved in fused alkali and alkaline earth nitrates and chlorides have been determined for the first time by means of high-temperature spectrophotometry. Information concerning coordination numbers in fused salts has been obtained by comparing absorption spectra of transition metal ions in crystals and in melts. An interesting technique for separating metal ions dissolved in fused salts has been developed. Oxidation-reduction reactions of actinide ions dissolved in LiCl-KCl eutectic have been studied spectrophotometrically. Fused salts present novel media in which to carry out chemical reactions. For example, the metals Zr, Th, U, Np, and Pu have been prepared from solutions in LiCl-KCl eutectic of $ZrCl_4$, $ThCl_4$, UCl_4, $NpCl_4$ and $PuCl_3$ by reaction with Mg metal. An attractive scheme for the preparation of U metal has been devised based on the reaction of the double salt Cs_2UCl_6 with Mg metal in a $CsCl \cdot MgCl_2$ fused salt matrix. (auth)

14614 A/CONF.15/P/2478
Nuclear Development Corp. of America, White Plains, N. Y.
RECENT TEST RESULTS OF SODIUM–WATER SYSTEMS. Norman R. Adolph, comp. and ed. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A sodium jet at 1050°F was directed at the inner surface of an 0.065 in. thick aluminum tube; simultaneously, a water jet at 150°F was directed at the same location but on the outer surface. During the course of this 14 minute test the tube bowed about $\frac{3}{8}$ in. in 2 ft; there was some local distortion, but the tube maintained its integrity. A mockup, representing part of a reactor lattice position, has operated successfully for several weeks. The test apparatus, which consists of a sodium loop, a water loop, and supporting gas systems, is demonstrating the feasibility of handling sodium and water under simulated reactor temperature conditions. (auth)

Analytical Procedures

14615 A/CONF.15/P/756
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
DETECTION OF PLUTONIUM IN WOUNDS. W. C. Roesch and J. W. Baum. 5p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A problem of long standing at plants handling plutonium is its detection in wounds from which the alpha particles cannot penetrate. About 4% of the disintegrations of plutonium are followed by emission of x rays of about 17 kev. Thin RaI crystals are very efficient

detectors of these rays (0.25 mm gives 95%) and have low backgrounds. Three cases of plutonium in wounds have been studied. Depositions of 0.0014 to 0.02 microcuries were found. After excision or strenuous decontamination, it was shown that less than 0.00004 microcurie was left. (auth)

14616 A/CONF.15/P/759
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
A SENSITIVE ANALYTICAL METHOD FOR THE DETERMINATION OF VERY LOW LEVEL PLUTONIUM IN HUMANS. L. C. Schwendiman and J. W. Healy. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A method was developed for determining extremely low levels of plutonium in urine. This method involves sample evaporation, muffling, dissolution of salts, coprecipitation with lanthanum fluoride, and chelation with thenoyltrifluoroacetone to isolate the plutonium. An electrodeposition method subsequently separates and deposits the plutonium uniformly on a small known area of a disc. Alpha track film is used to record the emission of alpha particles over a period long enough to give requisite sensitivity. After emulsion development, the tracks are counted under a microscope. A detection limit on the order of 0.03 d/m/sample (2×10^{-3} g plutonium) is achieved. This detection limit permits recognition of exposure at a level of 0.005 of the maximum permissible body burden, thus insuring timely detection of incipient deposition. (auth)

14617 A/CONF.15/P/796
Oak Ridge National Lab., Tenn. and Sanitary Engineering Center, Cincinnati.
NEUTRON ACTIVATION ANALYSIS OF DRINKING WATER. R. L. Blanchard, G. W. Leddicotte, and D. W. Moeller. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Drinking water samples collected from various geographical locations throughout the United States were analyzed by neutron activation. Each sample was analyzed qualitatively and quantitatively, and trace concentrations of aluminum, argon, arsenic, barium, bromine, iodine, manganese, rubidium and thorium, none of which had been detected, or determined, by conventional water analysis methods, were determined. In addition, calcium, copper, iron, magnesium, potassium, sodium, strontium, zinc, chlorine, and silicon, usually determined by routine water assay methods, were also determined. The radionuclides produced in the reactions of the stable isotopes with either thermal or fast neutrons in the Oak Ridge National Laboratory Graphite Reactor were used. Each analysis consisted of an irradiation of a portion from each sample in the reactor, and analysis either by direct radioactivity measurement or by radiochemical separation before the radioactivity measurement. Gamma counting, especially scintillation spectrometry, was used most frequently in making the radioactivity measurements. Gamma spectral analysis and half-life determinations were used to identify the induced radionuclides. In the quantitative analyses, a comparator sample containing a known amount of the element of interest, was irradiated and processed simultaneously with the unknown samples. Methods and procedures of sample irradiation and measurement of induced radioactivities are described. (auth)

14618 A/CONF.15/P/841
Brookhaven National Lab., Upton, N. Y.
APPLICATION OF ACTIVATION ANALYSIS TO BIOLOGICAL AND MEDICAL RESEARCH. Donald C. Borg. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The advantages, limitations, and scope of application of activation analysis in biology and medicine are discussed. An example given in some detail is that of Mn^{56} in tissue. (T.R.H.)

14619 A/CONF.15/P/858
Pennsylbania State Univ., University Park.
APPLICATION OF THE NUCLEAR REACTOR IN BIOCHEMICAL ANALYSIS: NEUTRON ACTIVATION CHROMATOGRAPHY. A. A. Benson. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Activation of paper chromatograms by slow neutron capture in the nuclear reactor has proved useful in biochemical research. The biological trace elements, cobalt and vanadium, were separated from ashed tissues and determined by measurement of radioactivity induced on the paper chromatograms. Since all chemical separations are performed before activation the metastable Co^{60m} (11 min) and 3.7 minute V^{52} were used for the analysis. Phosphorus-31 of the intermediates of carbohydrate and lipid metabolism is readily activated on paper chromatograms. The method has been used to obtain accurate and unequivocal analyses of the phosphatides of large animals. The phosphatidyl glycerols have been found in bovine spermatozoa. Neutron activation of sulfur compounds of biochemical interest is indicated. (auth)

14620 A/CONF.15/P/914
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
ANALYSIS FOR PLUTONIUM BY CONTROLLED POTENTIAL COULOMETRY. F. A. Scott and R. M. Peekema. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A method for the determination of the plutonium content of reactor fuels has been developed using controlled potential coulometry. This method is superior to conventional procedures because it is independent of the plutonium isotopic content, has greater precision and sensitivity, and can be used for plant feeds and in-process solutions as well as the plutonium product. The plutonium content of solutions has been determined over a wide concentration range with a precision of from ± 0.1% to ± one % on samples containing from two to 0.05 mg, respectively. Either mercury or platinum electrodes are used, and the method is simple with a minimum of sample pretreatment and no chemical adjustment of valence state necessary. In the course of the work, the polarographic behavior of Pu(IV) was studied in detail in many media. Interferences have been studied, particularly of reactor fuel alloying elements and fission products, and tolerable levels of common interfering ions defined. The method has been applied to the determination of the plutonium content of metal pieces with a precision of ± 0.1% at the 95% confidence level, and also to the direct estimation of the plutonium content of reactor fuel processing solutions. (auth)

14621 A/CONF.15/P/918
Ames Lab., Ames, Iowa and Iowa State Coll., Ames. Inst. for Atomic Research.
ANALYSIS OF THORIUM. Charles V. Banks. 40p. (ISC-1031). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The following methods for the determination of thorium are outlined: gravimetric, titrimetric, spectrophotometric, polarographic, qualitative detection, separation by extraction, ion exchange, and adsorption. X-ray fluorescence, emission spectroscopic, radiochemical, and mass spectrometric determinations and analyses for impurities are available. (J.E.D.)

14622 A/CONF.15/P/926
Los Alamos Scientific Lab., N. Mex.
THE CHEMICAL ANALYSIS OF PLUTONIUM-RICH FAST REACTOR FUEL. Charles F. Metz, George M. Matlack, and Glenn R. Waterbury. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The basic chemistry of plutonium applicable to the analysis of plutonium-containing materials is described. Included are, potentiometric methods for plutonium assay, radiochemical methods for gamma-counting of americium in plutonium, and methods of separating plutonium for measurement by alpha-counting techniques. Ion exchange methods and precipitation methods are discussed for separating plutonium from a number of alloying elements. Spectrochemical methods and micromethods are discussed for the determination of trace impurities. Methods of analysis, chemical and radiochemical, of plutonium-rich fast reactor fuel for major fission elements are included. Of very great value in the identification of plutonium compounds has been the study of the optical properties of their crystals under the polarizing microscope. A description of these techniques is also included. (auth)

14623 A/CONF.15/P/927
Oak Ridge National Lab., Tenn.
THE USE OF NEUTRON ACTIVATION ANALYSIS IN ANALYTICAL CHEMISTRY. G. W. Leddicotte, W. T. Mullins, L. C. Bate, J. F. Emery, R. E. Druschel, and W. A. Brooksbank, Jr. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The use of activation analysis by analysis at ORNL is reviewed. The ORNL program has provided much information on the method's practical use in the analysis of many different type samples. It has been used in reactor technology studies to determine uranium in low-grade ores, argon and xenon in reactor cooling water, and trace elements in reactor structural materials. It has also been used to determine trace elements in radioisotope "target" materials, oxygen in metals, sulfur and phosphorous in metals, fine chemicals and organic materials, and arsenic in petroleum. Other materials such as animal tissue, petroleums, grasses and grains, glass, ceramics, and metals and alloys have been analyzed for other trace elements. Activation analysis has also been coupled with existing sedimentation and centrifugation techniques of particle size analysis to provide a new method of analyzing particle size distributions in samples of thorium oxide, uranium dioxide and of mixed metal oxides. So far, it has been possible to use this application to analyze samples having a particle size distribution range of from 0.08 to 120 microns. The methods of analysis used are described and typical results obtained are reported. Detailed information is presented regarding the use of gamma spectrometry in analysis, choice of nuclear reactions, and the techniques of the particle size analysis method. (auth)

14624 A/CONF.15/P/953
Argonne National Lab., Lemont, Ill. and Chicago. Univ. Enrico Fermi Inst. for Nuclear Studies.
ACTIVATION ANALYSIS FOR HEAVY ELEMENTS IN STONE METEORITES. George W. Reed, K. Kigoshi, and Anthony Turkevich. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The interaction of neutrons with an element to produce radioactivity characteristic of the element is becoming a very useful method of analysis. One of the very special advantages of this analytical method is in determinations of minute concentrations of certain elements—concentrations so small that contamination from reagents or dust can introduce appreciable errors when using other techniques. The method has been applied to the determination of uranium in meteorites. It has been found that four chondritic meteorites have, within about 10%, the same amount of uranium (1.1×10^{-8} g/g); the amount of uranium in iron meteorites is at the limit of sensitivity of the method with the neutron fluxes available (10^{-11} to 10^{-12} g). The results on both stone and iron meteorites are factors of 10 to 100 lower than most previous determinations. (auth)

14625 A/CONF.15/P/954
Argonne National Lab., Lemont, Ill.
ANALYTICAL CHEMISTRY IN A NUCLEAR RESEARCH AND DEVELOPMENT LABORATORY. R. W. Bane and J. K. Brody. 25p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The importance of a strong, versatile, analytical group and the valuable contributions it can make in a nuclear research and development laboratory is discussed. Included in the analytical techniques developed in connection with atomic research are manometric methods for trace amounts of C, H, and O, a direct reading fluorescence photometer, an ion exchange separation useful in separating lithium from radioactive uranium and fission products, and a sensitive flame photometric technique. Assay of uranium in radioactive materials was facilitated by a continuous ether extractor. Spectrophotometric, polarographic, and potentiometric methods were applied in the analysis of reactor components including graphite, liquid metal coolants, refractory elements, and materials of construction. In addition, chemical methods were developed for the analysis of some complex metal alloys and ceramics encountered in research and in fuel element production. (J.R.D.)

14626 A/CONF.15/P/1833
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
SUMMARY OF ANALYTICAL METHODS USED IN THE CHEMICAL PROCESSING PLANTS AT HANFORD. R. J. Brouns and R. A. Schneider. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The principal methods used are discussed, including tests of the quality of final product material and the determination of certain nuclides which are important from the standpoint of process control, waste disposal, and by-product recovery. Routine uranium measurements are made by x-ray absorption, fluorimetry, or calculation from solution density. Plutonium concentra-

tions are measured by alpha counting or ceric titration. Acid concentration measurements are made by pH determination or coulometric titrations. Spectrographic analysis, chemical assay, and fission product activity are the principal product quality measurements used. The most important analytical methods associated with waste disposal operations include determinations of cesium-137, cobalt-60, and strontium-90. (J.R.D.)

Crystallography and Crystal Structure

14627 A/CONF.15/P/718
Chicago. Univ. Inst. for the Study of Metals.
SELF-DIFFUSION IN LIQUIDS AND CRYSTALLINE SOLIDS. Norman H. Nachtrieb. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The results of self-diffusion studies as a function of both temperature and pressure are presented for crystalline sodium, phosphorus, and lead (unpublished). Isotherms (pressure variable) lead to values for the activation volume in these solids which are of the order of the gram atomic volume. By contrast, similar isotherms for liquid gallium and liquid mercury give activation volumes which are smaller by an order of magnitude. The significance of these differences, together with the large discrepancies between D_0 values for solids and liquids, is pointed out. It is concluded that the mechanisms of atom movements may be quite different for the two states. While atom movements in crystalline solids take place by discrete "jumps" through interatomic distances, the movements of atoms in monatomic liquids appear to be small and to involve the cooperation of many neighbors. Recent unpublished results are presented on the self-diffusion of both components of the solid solution binary alloys of silver-palladium and lead-thallium as a function of temperature and composition. The silver-palladium study is interpretable in terms of the phase diagram by a corresponding states argument. An unexpected maximum in the self-diffusion rate of both lead and thallium is observed at 20% thallium concentration. (auth)

Deuterium and Deuterium Compounds

14628 A/CONF.15/P/1063
Little (Arthur D.) Inc., Cambridge, Mass.
SOME ASPECTS OF HEAVY-WATER PRODUCTION BY DISTILLATION OF HYDROGEN. B. M. Bailey. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An investigation has been carried out to provide further insight into some technological aspects of a plant for heavy-water production by distillation of hydrogen from an ammonia synthesis-gas feed. An existing plant design has been reappraised for the potential economic advantages accruing to it by application of lately-developed techniques of insulation. A pilot-scale experimental plant has been operated to evaluate the use of reversing heat exchangers for removal from the hydrogen feed stream of nitrogen below its triple-point temperature. Results of the insulation studies indicate an increase in the economic advantage of heavy-water production by low temperatures over other processes. The reversing heat-exchanger experiment confirmed analytical predictions which indicate that complete removal of nitrogen from an ammonia synthesis-gas feed requires solid condensate filtering in order to avoid equipment fouling by solid nitrogen in the extreme low-temperature regions of the plant. Over-all results of the process study indicate no major obstacles to reduction to practice of this method of heavy-water production. (auth)

14629 A/CONF.15/P/1065
Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Augusta, Ga. and Du Pont de Nemours (E. I.) & Co. Atomic Energy Div., Wilmington, Del.
CONCENTRATION OF HEAVY WATER BY DISTILLATION AND ELECTROLYSIS. William P. Bebbington and Victor R. Thayer. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Heavy water is extracted from natural water at the Savannah River Plant using a combination of three processes: (1) Dual temperature exchange between hydrogen sulfide and water. The product from this step contains about 15% D_2O. (2) Vacuum distillation, which carries the concentration to about 90% D_2O. (3) Electrolysis, which takes the concentration to 99.75% D_2O, the desired end product. A combination of vacuum distillation and electrolysis was used in 1944-45 to produce heavy water for the "Manhattan Project." Distillation carried the concentration from natural abundance to about 90% D_2O. The distillation process has certain advantages, particularly under conditions of a war economy, in that the equipment can be rapidly built from readily available materials, and operation is straightforward. These features were conducive to a minimum over-all elapsed time for design, construction, and plant startup. The distillation process is used regularly at Savannah River to upgrade heavy water that has been diluted while in use as reactor moderator. The simplicity and dependability of the process make it particularly useful for this purpose. The chief disadvantage of distillation as a means of producing heavy water directly from natural water is the high heat consumption. There are two possibilities for overcoming this disadvantage: (1) Use of waste heat, where such is available. (2) Use of the "heat pump" principle, by compressing the vapor leaving the top of a distillation tower, thereby raising the temperature sufficiently so that the compressed vapor (steam) can be used as a source of reboil heat for the tower. In principle this will reduce the energy requirements by a large factor, compared to the usual distillation practice. This method of heat recovery in distillation has apparently never been practiced on large scale, probably because in most distillation plants heat is not a major factor in the economy. (auth)

Fluorine and Fluorine Compounds

14630 A/CONF.15/P/524
Oak Ridge Gaseous Diffusion Plant, Tenn.
MULTI-TON PRODUCTION OF FLUORINE FOR MANUFACTURE OF URANIUM HEXAFLUORIDE. A. P. Huber, J. Dykstra, and B. H. Thompson. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The evolution and operation of full-scale fluorine production facilities are described. Flow diagrams, scaled drawings of process equipment, and photographs of systems and individual items of equipment are presented. (W.D.M.)

14631 A/CONF.15/P/922

Illinois Inst. of Tech., Chicago. Armour Research Foundation.

THE RADIATION CHEMISTRY OF FLUORINATED ORGANIC COMPOUNDS. P. Y. Feng. 14p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Although organic fluorine compounds have exceptional physical and chemical properties, development of their application is often limited by practical difficulties with synthesis. Much of the difficulty is a direct consequence of the high reactivity of the fluorine and the high stability of the C-F bond. Metathetical reactions provide a convenient route for the preparation of the fluorochemicals and it is pointed out that such reactions are possible with nuclear techniques. Fundamental information on the radiation chemistry of organic fluorine compounds is presented. A series of selected fluorine compounds in both the pure state and as mixtures were studied. The methods used included scavengers, polymer degradation, and product analysis. The results show that organic fluorine compounds are considerably more stable than their other halogen counterparts and compare with the hydrocarbons in radiation sensitivity. Such behavior is explained by the fact that dissociative electron attachment is possible for C−Cl, C−Br, and C−I bonds but not for C−F bonds with electrons of thermal energy. In addition, the very strong electron seeking character of fluorine serves to rule out any significant contribution to the radiation sensitivity of fluorine compounds due to the inductive effect. A comparison of the radical yield results and the product analysis shows that reactions such as $CF_4 + C_6H_6 \rightarrow C_6H_5F$ (or $C_6H_5CF_3$) + CHF_3 (or HF) cannot be explained by radical processes alone. A number of possible mechanisms, including the formation of ionic intermediates, are discussed. Studies of organic halogen compounds containing more than one halogen atom are also reported. The data are examined from the viewpoint of Burton's statistical principle and the effect of chemical structure is discussed. (auth)

14632 A/CONF.15/P/930

Oak Ridge Gaseous Diffusion Plant, Tenn.

MOLECULAR PROPERTIES OF HYDROGEN FLUORIDE. D. F. Smith. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The vibrational and rotational constants of hydrogen fluoride have been evaluated from the frequencies of the lines of the rotation and vibration-rotation spectrum. The intensities of the lines of the fundamental vibration-rotation band, when used with the internuclear distance, 0.9171 A, indicate that the dipole moment increases at the rate of 1.6 Debye units per Angstrom as the internuclear distance is increased. The permanent dipole moment, 1.736 Debye units, was determined from dielectric constant measurements at microwave frequencies. In addition to the hydrogen fluoride vapor spectrum of monomer, the polymer spectrum has also been studied. It has been established that this polymer spectrum originates from dimeric, tetrameric, and hexameric hydrogen fluoride, with dimer and tetramer always minor constituents. From the dielectric constant studies, the 2nd virial coefficient of the monomer is found to be sizable. When this is taken into account, the vapor density measurements can be reconciled with the present interpretation. The hexamer has a small dielectric constant and probably has a cyclic structure. In addition to the hydrogen fluoride polymers, the spectrum of vapor phase mixtures sometimes contains a band of a molecular complex such as $ClF_3 \cdot HF$, $SO_2 \cdot HF$, or $CO_2 \cdot HF$, present in very small concentration. On the other hand, large concentrations of complexes are found from the spectrum of mixtures of hydrogen fluoride with vapors of diethyl ether, acetone, and methanol. In dilute liquid solutions, the spectrum of hydrogen fluoride contains bands of hydrogen fluoride polymer. In very dilute solutions the polymer spectrum is reduced in intensity. With some solvents, such as uranium hexafluoride and molybdenum hexafluoride, the absorption remaining corresponds to monomeric hydrogen fluoride. In other cases, as with bromine trifluoride, sulfur dioxide, and chlorine trifluoride, the hydrogen fluoride absorption corresponds to a molecular complex which obscures the monomer absorption. The adjustment of the concentrations in a mixed solvent, such chlorine trifluoride-molybdenum hexafluoride, can be so accomplished as to permit the observation of both monomer and complex bands. (auth)

14633 A/CONF.15/P/937

Oak Ridge National Lab., Tenn. and Florida. Univ., Gainesville.

THE USE OF F^{18} IN PREDICTING CATALYTIC REACTIONS. John A. Wethington, Jr., T. A. Gens, W. H. Christie, and A. R. Brosi. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

F^{18} was used to study exchange reactions between metallic fluorides and fluorocarbons at room temperature. Cesium fluoride was the most reactive salt, however, measurable exchange was observed with all of the alkali fluorides. Perfluoropropene exchanged more readily than CF_4, C_4F_{10}, or $(C_2F_5)_2O$; however, measurable reaction was observed in all cases. Detailed studied with perfluoropropene and cesium fluoride at 0°C showed that the gas underwent exchange with the first ten to forty layers of the crystal at a rate too fast to be measured. This fast reaction was followed by a slow, apparently zero-order reaction, which if allowed to proceed, reached isotopic equilibrium with the entire crystal. Changes within the crystal could also be followed as the reactions proceeded. The oxidation of perfluoropropene was then studied using these inorganic fluorides as catalytic surfaces. The alkali fluorides were found to be excellent oxidation catalysts, and the ability of these salts to catalyze the oxidation reaction was in the same order as the extent of the fast initial exchange reaction. The distribution of products obtained when the salts were used as a reactor packing was vastly different from the products obtained from the thermal reaction. Processes within the crystal, were found to agree with those predicted by the exchange reactions. (auth)

14634 A/CONF.15/P/942

Argonne National Lab., Lemont, Ill.

SOME RECENT STUDIES WITH HEXAFLUORIDES. Bernard Weinstock and John G. Malm. 10p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A method of preparation for NpF_6 in gram quantities is described, and the results of studies with this compound as well as recent work with UF_6 and PuF_6 are presented. The physical properties of these three compounds behave in an anomalous fashion; a thermodynamic basis to explain this behavior is given. Preceding the 5f transition series hexafluorides is another group of

hexafluorides formed by the 5d transition series elements, W, Re, Os, Ir, and Pt. The preparation and study of OsF_6 is reported; this is of particular interest since this compound has been shown to be identical with the previously reported OsF_8. An octafluoride has never been prepared and the compound previously reported as OsF_8 was also incorrectly identified. The first preparation of a hexavalent compound of platinum, PtF_6, is also described as well as some of its properties. This compound appears to be the most reactive and unstable of all the hexafluorides. (auth)

14635 A/CONF.15/P/1775

Argonne National Lab., Lemont, Ill.

THE RADIOACTIVE ISOTOPE F^{18}: PREPARATION, PROPERTIES AND USES. R. M. Adams, I. Sheft, and J. J. Katz. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The isotope F^{18} is produced in a betatron, cyclotron, or nuclear reactor using various nuclear reactions. Studies have been made using F^{18} in many chemical problems of fluorine compounds. The kinetics of the gas-phase exchanges between ClF_3, BrF_5, IF_7, and F_2 in the temperature range 200 to 300°C show that the ClF_3-F_2 and IF_7-F_2 exchanges may be interpreted on the basis of a homogeneous dissociative exchanges plus a heterogeneous exchange taking place on the NiF_2-coated surface of the exchange vessel. Isotopic exchange between solid inorganic fluorides and gaseous fluorocarbons has also been studied using F^{18}. Potential application of F^{18} to problems in analysis, industry, and fundamental and applied research is discussed. (J.E.D.)

Graphite

Refer also to abstract 15040.

14636 A/CONF.15/P/614

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

DAMAGE EFFECTS TO GRAPHITE IRRADIATED UP TO 1000°C. R. E. Nightingale, J. M. Davidson, and W. A. Snyder. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Irradiation effects at 500°C in experimental graphites with varied density, crystallinity, surface area, and pore distribution are discussed. Changes in macroscopic properties are dependent upon the initial crystallite structure; however, the mechanism by which the increase of interlayer spacing and decrease of apparent crystallite size effect these changes is not well understood. Macroscopic properties are also dependent upon the arrangement of crystallites and whole coke particles within the over-all structure which radiation may change slightly. Graphite irradiations in the Materials Testing Reactor extend exposure temperatures from 600 to 1000°C. The temperature coefficient of property damage decreases with temperature, and only slightly less damage occurs at 1000°C than at 500°C. Thermal conductivity decreases by a factor of 50 with 30°C irradiation, a factor of 3 with 500°C irradiation, and a factor of 2 with 750°C irradiation. Within the irradiation temperature range 500 to 1000°C, the contraction rate after the first 1500 Mwd/t is measurably the same: C_0 spacing expands slightly; and apparent crystallite size decreases by one-half. The total stored energy content is decreased with increased irradiation temperature. The way in which damage effects in irradiated graphite are distributed may be measured by the ease with which they may be thermally annealed. By estimating an activation energy for a given temperature-time annealing and measuring the amount of property annealed, at repeated increasing temperatures, it has been possible to characterize the damage with a damage distribution curve. Thermal annealing experiments on graphites with varied exposures and temperatures of irradiation have included property measurements of dimensions, thermal conductivity, interlayer spacing, and crystallite size. A damage mechanism is discussed which attempts to correlate and explain the changes in properties resulting from graphite irradiations at high temperature. Since the average crystallite does not contract (C_0 expands slightly) while the density of the graphite increases, reactor radiation at high temperature must result in a more efficient packing of the crystallites. Damage distribution curves of samples irradiated at a variety of temperatures can be understood in terms of a process whereby energetic carbon atoms transfer a large amount of energy to the lattice close to a crystal defect. In this way, the activation energy for annealing which is in excess of equilibrium lattice temperature is supplied to the damaged lattice. (auth)

14637 A/CONF.15/P/702

Los Alamos Scientific Lab., N. Mex.

SOME MECHANICAL PROPERTIES OF GRAPHITE IN THE TEMPERATURE RANGE 20° TO 3000°C. P. Wagner, A. R. Driesner, and E. A. Kmetko. 28p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Measurements were made on the following high temperature mechanical properties of graphite: strength in tension and compression, tensile and compressive creep, coefficient of friction, coefficient of thermal expansion, and thermal conductivity. These measurements were performed to study the effects of temperature, stress level, anisotropy, and graphite type. Included in graphite type were graphites manufactured with normal uranium carbide in the graphite matrix. The maximum concentration of the uranium used was 350 mg/cc. (auth)

14638 A/CONF.15/P/1778

Argonne National Lab., Lemont, Ill.; Brookhaven National Lab., Upton, N. Y.; and General Atomics Div., General Dynamics Corp., San Diego, Calif.

RADIATION EFFECTS ON THE OXIDATION RATE AND ON OTHER CHEMICAL PROPERTIES OF GRAPHITE. G. R. Hennig, G. J. Dienes, and W. Kosiba. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Irradiation by fast particles changes most physical and chemical properties of graphite by producing various lattice defects such as displaced atoms, vacancies, dislocations, etc. Attempts have been made to evaluate the contributions of different types of defects to the property changes. Such evaluations have proven rather successful for physical properties and will be extended to several chemical properties. Experiments are described which show that oxidation catalysts and inhibitors act differently on irradiated and on unirradiated crystals. The oxidation of graphite crystals in ozone was studied because it appears to provide clues to the enhancement of oxidation rates in the presence of ionizing radiation. The kinetics and mode of attack of ozone on graphite crystals with or without prior neutron irradiation are described. (auth)

Laboratories and Equipment

14639 A/CONF.15/P/531
Los Alamos Scientific Lab., N. Mex.
THE LOS ALAMOS PLANT FOR REMOTELY CONTROLLED PRODUCTION OF PLUTONIUM METAL. A. N. Morgan, Jr., R. D. Baker, W. C. Hazen, A. V. Henrickson, W. D. McNeese, and R. L. Thomas. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Plutonium metal has been produced in kilogram quantities in remotely controlled equipment at the Los Alamos Scientific Laboratory since 1951. The chemistry consists of peroxide precipitation of plutonium from a nitrate feed solution, conversion of the peroxide to plutonium tetrafluoride, and reduction of the tetrafluoride to plutonium metal. The aqueous chemistry is performed in a glass reaction vessel. Solid plutonium peroxide is separated from the supernatant liquid by filtering through a sintered platinum disc. Direct conversion to plutonium tetrafluoride is accomplished by passing anhydrous hydrogen fluoride through the peroxide cake. The tetrafluoride powder is then mixed with calcium, poured into a ceramic crucible and reduced to plutonium metal. Chemical operations are carried out on a batch basis. The unit consists primarily of an enclosed horizontal conveyor, which transports the plutonium between chemical processing stations, and pneumatic cylinders, for vertical transmission into each processing station. Incorporated in the design are features which exclude all accessory equipment from the contaminated enclosure. Each processing station is constructed as an integral part so that replacements can be made simply without spread of contamination. Manual servicing of the unit requires loading of the plutonium nitrate container, crucible and gasket, extraction of the plutonium pellet and residues, and maintaining reagent supplies. (auth)

14640 A/CONF.15/P/532
Los Alamos Scientific Lab., N. Mex.
HOT CELLS FOR PLUTONIUM REACTOR FUEL RESEARCH. P. J. Peterson, R. L. Thomas and J. L. Green. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The structure consists of four 6 ft. by 6 ft. by 10 ft. high cells in a line backed by a common corridor 11 ft. by 30 ft. long. Shielding is accomplished with a combination of magnetite and ordinary concrete. One pair of Argonne Model No. 8 manipulators are used in each cell and a General Mills Mechanical Arm, in the corridor. The former will be used for actual experimentation and the latter to transfer material into and out of the cells. Because of the types and quantity of plutonium to be handled, the material will be processed within a portable enclosure located in a cell. The enclosure is designed for versatility. The Model No. 8 Manipulators will have access to the interior of the enclosure through contamination-tight plastic booting developed at the Los Alamos Scientific Laboratory and can be remotely introduced and withdrawn. Their function is to perform the lighter tasks required and to service the mechanical aids used for heavier work. Services to the enclosure can be remotely disconnected and the enclosure can be remotely removed. Special services are ventilation, negative-pressure circulating water system, and induction heating facility. Plutonium is transferred to and from the enclosure in an alpha container by the Mechanical Arm. The container is attachable to the enclosure and the plutonium removed by remote operation without spread of contamination. (auth)

14641 A/CONF.15/P/533
Los Alamos Scientific Lab., N. Mex.
ANALYTICAL CHEMICAL LABORATORIES FOR THE HANDLING OF PLUTONIUM. C. F. Metz. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The analytical laboratories at Los Alamos equipped with dry and glove boxes are described and the philosophy of handling plutonium is presented. The boxes are so designed that all required operations in chemical analysis can be safely performed without room contamination and with minimum risk to the analyst. These boxes are fabricated of stainless steel, with windows of lucite or safety glass. All metal exposed on the inside is painted with a stripable plastic base paint. Glove ports at a convenient height permit easy use of rubber gloves. Experience has shown that plutonium in solution can be safely handled in these enclosures without rubber gloves on the ports, but for handling plutonium in solid form, rubber gloves must be attached to the glove ports. These enclosures are equipped with all the usual laboratory services. Doors between boxes are of an unusual design, vertically operated by compressed air. Provisions exist for operation of equipment such as centrifuges and pH meters within the boxes yet permitting removal in an uncontaminated condition. Ventilation is provided through filters for all gloved boxes and is regulated so as not to interfere with operations by means of dampers in the exhaust ducts. In case of open front boxes, a minimum face velocity of 100 feet per minute is maintained. Polyvinyl plastic was used for exhaust duct installations and was found to be quite satisfactory. (auth)

14642 A/CONF.15/P/543
Argonne National Lab., Lemont, Ill.
HOT LABORATORY FACILITY FOR PHYSICAL MEASUREMENTS ON IRRADIATED PLUTONIUM. R. C. Goertz. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A new facility is being developed to carry out physical measurements on irradiated plutonium-bearing fuel elements. The shielded enclosure (cave) will be sealed tight enough to contain the radioactive particulate material and a portion of it will be tight enough to contain a high purity inert atmosphere. Handling and manipulation within the enclosure are to be performed entirely by remotely controlled slave-robots, manipulators, and cranes. Viewing will be by means of shielding windows, periscopes, and television. Slave-robots are to have capabilities of setting up, operating, and repairing or removing any of the equipment to be used in the facility. The ability of one slave-robot to repair another similar unit is the first requirement for achieving the over-all objective. In addition, the other equipment used in the caves must be designed so that the slave-robots, along with the other manipulators and cranes, can repair or replace them. The emphasis will be on repair rather than replacement because much of the equipment for experimental research will be new and unproven. A simple slave-robot, Model 1, has been built and improved models are under development. One of these is expected to be built in 1958 and still another improved model in 1959. (auth)

14643 A/CONF.15/P/1829
Los Alamos Scientific Lab., N. Mex.
RECENT DEVELOPMENTS IN FACILITIES FOR HANDLING INTENSE ALPHA SOURCES. W. J. Maraman. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The design criteria incorporate operational workability, material transfer mechanisms, personnel safeguards, materials of construction, ventilation, and equipment maintenance. The module concept for chemical, metallurgical, and analytical work and enclosures for specific equipment are discussed and illustrated. Transfer mechanisms, conveyor tunnels and sequential operations in glove boxes are used to minimize the contamination hazard where material is moved into or from an enclosure. In addition to the normal industrial safety practices, exacting precautions are taken to prevent lacerations or burns of personnel and explosions within the glove box. Austenitic stainless steels are the best all-round material of construction. The potential fire hazard of plutonium and uranium metal has restricted the use of many plastic and other flammable materials. Enclosure and operating-area ventilation systems are separate, the exhaust from glove boxes is drawn through successive banks of fire-resistant ultrafilters and operating-area air is discharged through a single filter bank. (auth)

14644 A/CONF.15/P/1903
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
DESIGN AND OPERATION OF HANFORD'S PLUTONIUM METALLURGY FACILITIES. O. J. Wick and I. D. Thomas. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The philosophy of plutonium handling on a large scale is described in detail. Descriptions are presented of the enclosure of full size ceramic and metal fabricating equipment in glove boxes for fabrication development and pilot plant verification of new manufacturing processes for reactor fuel materials containing plutonium. Emergency procedures are outlined for both major and minor incidents in order to minimize the spread of contamination and assure personnel safety. Methods and techniques employed in decontamination of grossly contaminated facilities are presented as well as design considerations which effectively decrease the labor and equipment loss resulting from such an accident. (auth)

Radiation Chemistry

14645 A/CONF.15/P/795
Esso Research and Engineering Co., Linden, N. J.
THE USE OF NUCLEAR RADIATION IN CHEMICAL PROCESSING OPERATIONS. Frank T. Barr, H. J. Ogorzaly, and T. A. Teiter. 9p. $0.50(OTS).

A review of radiation sources and methods for process applications is presented, including observations on limitations and economics. Sources of radiation for promotion of chemical reactions include radioisotopes, accelerators, and nuclear reactors. Radioisotopes may be either fission products or materials activated in a reactor; they supply gamma radiation. Accelerators provide high energy electrons under more controllable conditions. Reactors can provide gamma, neutron, and recoil fission product radiation. Design studies for reactors supplying radiation to process streams passing directly through the core indicate that they are feasible and can be made safe. Another use of reactors is in supplying process heat. Because there is no flue gas to limit efficiency in the supply of high temperature heat from reactors, it is in this field that nuclear heating may be most attractive. The primary limitation is in materials of construction. Supply to the process stream may be either direct or through an intermediate agent. Nuclear reactors may also be used to supply process steam. A survey of possible systems for the practical utilization of nuclear energy in the process industries is included. Joint supply of radiation and heat, radiation and power, and of process heat, steam, and power is considered. (auth)

14646 A/CONF.15/P/805
Brookhaven National Lab., Upton, N. Y.
THE CONVERSION OF HIGH ENERGY RADIATION TO STORED CHEMICAL ENERGY AND ITS UTILIZATION IN THE FORMATION OF GRAFT COPOLYMERS. D. S. Ballantine, A. Glines, and D. J. Metz. 12p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Radiation-produced trapped free radicals in organic materials are discussed. The formation of trapped free radicals in thin films of polyethylene and their subsequent use in initiating the graft polymerization of styrene is described in detail. (T.R.H.)

14647 A/CONF.15/P/818
Northwestern Univ., Evanston, Ill.
THE RADIATION CHEMISTRY OF A TYPICAL MACROMOLECULE, POLYETHYLENE. Malcolm Dole, T. F. Williams, and A. J. Arvia. 14p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

By making a careful study of the infrared absorption spectra, the formation of ring-links or the cyclization of polyethylene in the solid state under the action of ionizing radiations was discovered. This effect as well as the formation of vinylene unsaturation is probably largely the result of ionic reactions inasmuch as the radiation yield is practically the same at liquid nitrogen temperature as at room temperature. Such an effect appears to depend upon the crystallinity of the polyethylene. A new discovery has been made concerning the influence of molecular hydrogen pressure upon the rate of hydrogen gas production during irradiation. Increase of hydrogen pressure lowers the yield, possibly due to a reaction involving chain scission and hydrogenation of the free radicals produced to form methyl groups. This and other phenomena are discussed. (auth)

14648 A/CONF.15/P/859
Argonne National Lab., Lemont, Ill. and Kansas. Univ., Lawrence.
STRUCTURAL DEGRADATION OF IRRADIATED PROTEIN. Charles A. Leone and Hugo Fricke. 7p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Irradiated protein systems contain molecules in various stages of structural degradation. Some of these degraded molecules are insoluble at their isoelectric point and on the basis of the conventional criterion will be described as denatured. Molecules in more moderately injured configurations can be detected since they denature more easily than the native. In order to study these labile molecules quantitatively the denatured constituents of an irradiated system are precipitated

and the kinetics of the thermal denaturation of the supernatant are studied over a broad temperature range. In the cases examined, the denaturation reaction is unimolecular and hence, in principle it is possible to characterize the labile constituents individually on the basis of such measurements. However, the irradiated systems are too complex to allow this problem to be solved practically. The radiation induced lability is associated with parallel decreases in energy and entropy of activation of the denaturation reaction. Optical rotation measurements indicate that the labile constituents are in states of partial unfolding of the peptide chain. Studies have been carried out to determine the role of the structurally degraded molecules in the loss of serological activity of irradiated ovalbumin. For this purpose, lyophilized ovalbumin is irradiated in a vacuum by γ-rays and later dissolved at pH 7 to 9 NaOH and 0°C. The serological activity was determined by observing, at pH 7.2 and 0°C, the precipitin reaction of the irradiated system with anti-native rabbit serum, over the complete range of antigen-antibody combining proportions. (auth)

14649 A/CONF.15/P/916
University of Notre Dame, Notre Dame, Ind.
A CONSIDERATION OF ELEMENTARY PROCESSES IN RADIATION CHEMISTRY. Milton Burton, William H. Hamill, and John L. Magee. 21p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Mechanistic details of chronology and geometry of energy absorption and dissipation and their chemical consequences as influenced by composition, physical state, and density are discussed. An adequate kinetic mechanism must account for all intermediate species and events. The immediate effects produced by charged particles involve energy loss by electrons, their reaction with molecules or positive ions, ion-molecule reactions and charge neutralization processes. The consequences of electronic excitation include migration, transfer and luminescence or quenching as well as dissociation of excited molecules. The chemistry of the resulting free radicals depends upon diffusion kinetics in particle tracks, and the reactions of radicals with scavengers. A summary of the status of knowledge of the elementary processes as derived from phenomenological studies combined with theoretical considerations is presented. (auth)

14650 A/CONF.15/P/920
California. Univ., Berkeley. Radiation Lab.
THE RADIATION SENSITIVITY OF CRYSTALLINE CHOLINE CHLORIDE. Richard M. Lemmon and Robert O. Lindblom. 9p. (UCRL-3982). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Nineteen crystalline analogs of choline chloride were prepared, and the radiation sensitivities of these compounds were determined. The radiation sensitivity was compared with that of the compound in solution. The rate of decomposition of the crystalline compound at low temperatures was determined. The nature of the free radicals involved in the radiation decomposition was investigated by the method of electron-spin resonance spectroscopy. (W.D.M.)

14651 A/CONF.15/P/923
Johns Hopkins Univ., Baltimore.
APPLICATION OF ISOTOPES TO BORON HYDRIDE CHEMISTRY. Walter S. Koski and J. E. Todd. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The exchange of deuterium and B^{10} between diborane and several of the more common boron hydrides was studied because a knowledge of the exchange mechanism gives a better insight into the nature of the intermediate fragments that play an important role in the chemistry of these compounds. Evidence has been accumulated for at least three mechanisms by which isotopic exchange proceeds in the boron hydrides. In the diborane self-exchange the reaction appears to involve borane as an entity and the ratio of deuterium rate to boron rate is three. In the $B_2D_6-B_5H_9$ exchange the rate-determining step is the reaction of borane with the terminal hydrogens of pentaborane. The bridge hydrogens are not involved at all and the borons do not exchange. A similar situation exists in the diborane-decaborane exchange. In the $B_2D_6-B_5H_{11}$ reaction the fraction-order kinetics indicate that the B_5H_{11} is fragmenting. All of the borons and all of the hydrogens in both molecules are participating in the exchange. Only one rate of exchange has been observed but there is experimental evidence that exchange can proceed by an intramolecular mechanism. In the case of the $B_2D_6-B_4H_{10}$ reaction one has at least two mechanisms of isotopic exchange and evidence has been obtained for an exchange that proceeds by an intramolecular mechanism. Kinetic measurements indicate that the tetraborane is fragmenting. The intramolecular process is an indication of the lability of the hydrogens and the borons in some of the less stable boron hydrides. Details of the measurements are discussed for the diborane-tetraborane exchange and the B^{10} self-exchange in diborane. The application of some of these results to pyrolysis reactions of boron hydrides is pointed out. (auth)

14652 A/CONF.15/P/949
Argonne National Lab., Lemont, Ill.
PHOTOCHEMICAL CONTRIBUTIONS TO RADIATION CHEMISTRY. Max S. Matheson. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The literature is reviewed for a comparison of photochemistry with radiation chemistry in studies on diffusion theory, track effects, rate constant measurements, G values, hot radical and ion-molecule reactions, and the reaction of specific fragments and excited states. It is suggested that the potential value of such comparisons has not been sufficiently exploited. (auth)

14653 A/CONF.15/P/951
Argonne National Lab., Lemont, Ill.
RECENT STUDIES ON REACTIONS IN IRRADIATED WATER. Edwin J. Hart. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Ionizing radiations create free hydrogen atoms and hydroxyl radicals in water. All phases from the ionization act to the final stages of complex chemical reaction are under investigation. This survey deals with recent research on diffusion theory, free radical yields, new radical species, chemical dosimetry, and the chemistry of some simple aqueous inorganic and organic reactions. (auth)

14654 A/CONF.15/P/1403
Brookhaven National Lab., Upton, N. Y.
DECOMPOSITION OF WATER UNDER HIGH ENERGY RADIATION. Augustine O. Allen and Harold A. Schwarz. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

New developments of the last two years allow a more

complete understanding of the decomposition of water by radiolysis. It was found that the "H atom" produced by the reaction $H_2 + OH \rightarrow H + H_2O$ behaves differently from the "H atom" formed from water by radiolysis. The direct formation of the radical HO_2 in the charged particle ion track has been established. (W.D.M)

14655 A/CONF.15/P/1769
Rensselaer Polytechnic Inst., Troy, N. Y.
RADIATION CHEMISTRY OF GASES. P. Harteck and S. Dondes. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The kinetic radiation equilibrium has only been obtained with two systems, nitrogen–oxygen, and carbon dioxide. In the case of the nitrogen–oxygen system, the end results are nitrogen, oxygen, nitrogen dioxide, and nitrous oxide, regardless of the initial material. Thus, if nitrous oxide or a 66.33 mixture of nitrogen to oxygen is the starting material, the concentrations of the reactants and products at the kinetic radiation equilibrium are identical. Analogous results are obtained with nitric oxide of a 50:50 mixture of nitrogen to oxygen and with nitrogen dioxide and a 33.66 mixture of nitrogen to oxygen. The carbon dioxide equilibrium yields carbon dioxide, carbon monoxide, and oxygen. (auth)

Radiation Effects

Refer also to abstract 14638.

14656 A/CONF.15/P/522
Oak Ridge Gaseous Diffusion Plant, Tenn.
RADIATION EFFECTS OF ALPHA PARTICLES ON URANIUM HEXAFLUORIDE. H. A. Bernhardt, W. Davis, Jr., and C. H. Shiflett. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Alpha irradiation of uranium hexafluoride results in the formation of fluorine and intermediate, solid uranium fluorides; these products react with each other, apparently by a radiation-induced process, to reform uranium hexafluoride. The number of molecules of uranium hexafluoride decomposed, excluding recombination, per 100 ev of energy absorbed, G , is approximately 1 in the temperature range 21 to 87°C. Irradiation of a mixture of fluorine and uranium hexafluoride in a vessel containing uranium fluorides substantiates the postulated mechanism. At fluorine pressures of 50 to 100 mm Hg, there is an increase, rather than a decrease, in uranium hexafluoride pressure. Rates of both decomposition and recombination processes appear to depend only on the rates of radiation energy absorption. Equations formulated to describe the combined decomposition and reformation reactions can be used to calculate equilibrium concentrations of uranium hexafluoride and fluorine when the intensity of the radiation source is defined. The effects of three diluent gases, helium, nitrogen, and oxygen, were studied in an attempt to find possible electron transfer processes. (auth)

14657 A/CONF.15/P/794
Purdue Univ., Lafayette, Ind.
THE EFFECT OF GAMMA RADIATION ON THE LOW-TEMPERATURE OXIDATION OF PROPANE. John L. Liebenthal, Lyle F. Albright, and Alexander Sesonake. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The effect of gamma radiation on the partial oxidation of propane with oxygen was studied in a Pyrex glass tubular reactor. Experimental runs were made in and out of a Co^{60} source which provided a gamma field of about 250,000 roentgens per hour; at feed gas temperatures of 350, 375, and 395°C; at residence times in the reactor of 2, 5, and 10 sec; and at mole ratios of propane to oxygen of 3:1, 5:1, and 10:1. Peroxides, methanol, formaldehyde, and acetaldehyde were found by mass spectrograph analysis to occur in significant quantities in all runs; however, radiation had a large effect on the yields of each. Other products detected in at least some runs include ethanol, isopropanol, acetone, and various acetals. Radiation at mole ratios of 5:1 generally increased the yields of peroxides, methanol, formaldehyde, and acetaldehyde, but decreased the amounts of oxides of carbon at the following conditions: contact times less than 6 to 8 sec, and temperatures of 375°C and especially 250°C. The aldehyde yields in particular were increased in some cases by as much as 100 to 200%. (auth)

14658 A/CONF.15/P/797
Esso Research and Engineering Co., Linden, N. J.
RADIATION INITIATED SULFOXIDATION OF HYDROCARBONS. James F. Black and Edmund F. Baxter, Jr. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Mechanism studies on the gamma radiation initiated reaction of SO_2 and O_2 with hydrocarbons to form sulfonic acids are discussed. These studies are of theoretical interest because they demonstrate G values ranging as high as 7000 for certain feed stocks; show that certain types of hydrocarbons are efficient inhibitors for this reaction; reveal steric hindrance effects which throw light on the structure of the chain carrying agents, and present evidence for an unusual type of chain reaction with delayed branching which is not explosive due to inherent quenching characteristics. The studies are of practical interest since they could lead to a radiation initiated process for the manufacture of new classes of water or oil soluble detergents. Conversions in the range of 40% per Mr of absorbed radiation were realized with cyclohexane and with pure normal paraffins varying from C_6 to C_{16} in molecular weight. Data were obtained which show that C = C and tertiary C-H bonds are efficient inhibitors for the sulfoxidation reaction. Such groups may account for the low yields observed in attempts to sulfoxidize broad boiling paraffin fractions derived from petroleum. Under certain conditions the sulfoxidation reaction has been observed to continue at an appreciable rate after irradiation was stopped. It was found that this behavior is a property of paraffins with an odd number of carbon atoms and can be correlated with the ability of the hydrocarbon to dissolve SO_2. The mechanism for the autocatalytic reaction is rendered more plausible by the proposal of a reaction step which will automatically regulate the branch chain reaction so that it does not lead to explosion. Evidence is presented to support this mechanism. (auth)

14659 A/CONF.15/P/808
Continental Can Co., Inc., Chicago.
RADIATION CHEMISTRY OF FOODS–1958. B. H. Morgan. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

During the last five years a great deal of technical effort has been expended in the United States in understanding the effect of ionizing radiations upon foodstuffs and preparing to apply this knowledge to industrial purposes. This paper is a comprehensive technical

status report on the results of the program, with the major emphasis on the knowledge secured on the effects of these radiations upon the food chemistry of the treated foodstuffs. It is not a general paper stating the broad goals and high points of the process. (auth)

14660 A/CONF.15/P/915
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
RADIATION SENSITIVITY AND CHEMICAL STRUCTURE. D. R. Kalkwarf. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The radiation sensitivity of a compound in aqueous solution is determined in many cases by its reactivity with the free radicals and other products formed by the irradiation of water. In order to examine the nature of radiation sensitivity, a method was devised for measuring relative reaction rates of compounds with the radicals formed in aerated water. Each compound was allowed to compete with the dye erioglaucine for the radicals formed in the same aqueous solution during radiolysis. The ratio of the rate constants for these reactions was then calculated from the measured bleaching rate of the dye, assuming both competitive reactions were bimolecular. For a large number of compounds, these ratios are constant over a fifty-fold change in concentration giving support to the assumed mechanism. The ratios then serve as numerical measures of the reaction rates for compounds with these radicals on an equimolar basis. Examination of a series of aliphatic alcohols showed that these ratios increase in the order tertiary < secondary < primary for alcohols with the same number of carbon atoms and also increase linearly with chain length in each of the above groups. Chain branching of the higher alcohols and substitution of other functional groups on the alcohol cause effects which indicate that structures in which a high electron density may be localized on one carbon atom react most rapidly with the radicals. The substituted benzoic acids also lend support to this view since substituents which tend to concentrate a high electron density at one or two carbon atoms in the aromatic ring also react rapidly. Compounds exhibiting large rate constants might serve as protective agents for living organisms. (auth)

14661 A/CONF.15/P/948
Argonne National Lab., Lemont, Ill.
RADIATION CHEMISTRY IN RIGID ORGANIC MATERIALS: THE DETECTION OF INTERMEDIATES. Max S. Matheson. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A discussion of the radiation chemistry of rigid noncrystalline systems is presented. Emphasis is centered on the use of a rigid matrix to trap reactive fragments, which are identified and studied for electron spin resonance. The hyperfine structure of ESR helps identify the radical or ion produced and gives information on the electronic structure of the fragment. The materials used in the paramagnetic resonance studies included several of the simpler hydrocarbons, alcohols and ethers, methyl alkyl compounds, and various plastics. (J.R.D.)

14662 A/CONF.15/P/952
Argonne National Lab., Lemont, Ill.
RADIATION DECOMPOSITION OF WATER UNDER STATIC AND BUBBLING CONDITIONS. Sheffield Gordon and Edwin J. Hart. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Operation of Borax III (Argonne Experimental Boiling Water Reactor) reveals much higher water decomposition rates than are found in non-boiling water moderated reactors. Hydrogen and oxygen in low concentrations appear in the effluent steam. Normally, in water moderated reactors, decomposition of water is not a serious problem since there is a large reserve γ-ray flux available for promoting the recombination reaction: $H_2 + H_2O_2 = 2H_2O$. But during shaking or boiling, the hydrogen escapes from the aqueous phase and the radiation induced decomposition of hydrogen peroxide leads to oxygen evolution: $2H_2O_2 = 2H_2O + O_2$. The kinetics of non-boiling irradiated water has been studied and reported in the extensive investigations of Allen and co-workers. Borax III experiments show, however, that the effectiveness of the recombination reaction is reduced appreciably during boiling. (auth)

14663 A/CONF.15/P/1128
Argonne National Lab., Lemont, Ill.
DECOMPOSITION OF AQUEOUS SOLUTIONS BY α-PARTICLES. Cemil B. Senvar and Edwin J. Hart. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Values for the initial alpha particle decomposition yields of H_2O_2 from water to study the effects of KI and I_2 as free radical scavengers are presented, and a comparison of the experimental results with theory for cylindrical diffusion is made. Polonium (Po^{210}) sources of 600 to 1300 mc were used, and the energy of the collimated alpha particle beam was 3.4 Mev. Deaerated, distilled water or iodide and iodide–iodine solutions at pH 4.0 were used. (J.R.D.)

14664 A/CONF.15/P/1426
Yale Univ., New Haven.
CHEMICAL PROPERTIES OF HIGH-ENERGY HYDROGEN AND CARBON PRODUCED BY NUCLEAR REACTIONS. Richard Wolfgang. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The reactions by very high kinetic energy tritium produced by the $Li^6(n,\alpha)H^3$ and $He^3(n,p)H^3$ reactions were studied, and an investigation of the properties of uncombined carbon atoms produced by the $N^{14}(n,p)C^{14}$ reaction have been started. In earlier studies it was shown that when tritium produced by nuclear reaction is allowed to recoil into organic materials it reacts to eject and replace hydrogen atoms. This finding led to a new method of direct production of tritium-labeled tracer molecules. The work reported has led to a model of the mechanism of these high energy reactions of hydrogen atoms. Reactions of recoil hydrogen with a number of simple gaseous hydrocarbons under a wide variety of conditions were investigated. The data obtained indicate that recoil tritium reacts to become chemically combined in a high-energy collision. The tritium-labeled species produced in this primary replacement reaction may be either stable molecules or radicals (e.g., CH_3^3H). Those tritium-labeled radicals reaching thermal energies will then undergo much slower secondary reactions, such as hydrogen abstraction, to eventually also yield stable labeled molecules. (auth)

14665 A/CONF.15/P/1779
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
A STUDY OF THE POLYPHENYLS FOR USE AS MODERATORS AND COOLANTS IN NUCLEAR POWER REACTORS. C. A. Trilling, D. W. Bareis, J. G. Burr,

and R. H. J. Gercke. 49p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The predicted stability of aromatic hydrocarbons to radiation and heat was confirmed by an extensive experimental program. This experimental work was divided into three phases: (1) a basic program to measure the physical properties of the polyphenyls of interest and to determine the effects of radiation damage upon these properties; (2) an engineering program to study the behavior of the polyphenyls under process conditions; and (3) operation of two in-pile loops to study the rate and the effects of radiation damage to the polyphenyls under reactor conditions and to provide samples of irradiated materials for the other two programs. The two in-pile loops were operated at high temperatures in the Materials Testing Reactor. The fluids tested included diphenyl, the eutectic mixture of diphenyl and ortho-terphenyl, isopropyl diphenyl and two different mixtures of terphenyls. The results showed that the rates of damage under irradiation were approximately the same for all the fluids tested and of the same order of magnitude as previously measured in capsule experiments under electron and reactor irradiations. There was no appreciable deposition of high boiling materials on the heat transfer surfaces, and the observed changes in heat transfer properties could be attributed to the increase in viscosity of the fluids under irradiation. The physical properties of these hydrocarbons were measured as a function of temperature and of radiation damage. Changes in density, hydrogen density, viscosity, heat capacity, vapor pressure and melting point were determined. Heat transfer characteristics of irradiated and unirradiated polyphenyls were determined in a laboratory loop, together with high temperature fouling and burn-out heat transfer data. Purification of the damaged hydrocarbons was studied in a bench-scale distillation unit. (auth)

14666 A/CONF.15/P/1866

General Electric Co. Research Lab., Schenectady, N. Y.

EFFECTS OF PSEUDO FISSION GASES IN METALLIC LATTICES. D. W. Lillie. 26p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The effects of neutron irradiation on the properties of Mg–Li alloys of compositions 87% Mg–13% Li and 96% Mg–4% Li were investigated as an analog to the production of xenon and krypton in irradiated uranium. Irradiations were carried out in CP-5 reactor at fluxes of 2×10^{13} NV thermal to burnups of 0.17% of total atoms in the most extreme case. Data are presented on the effects of irradiation on dimensions, x-ray parameters, electrical resistance, and mechanical properties (tensile strength and ductility). Metallographic examination is also discussed. Similarity of behavior of these alloys to uranium is discussed. (M.H.R.)

Rare Earths and Rare-earth Compounds

14667 A/CONF.15/P/941

Argonne National Lab., Lemont, Ill.

REACTION KINETICS OF THE ACTINIDE ELEMENTS. J. C. Hindman. 29p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An effort has been made not only to summarize the available data but also to determine what the principal factors governing the rates of the different kinds of reactions are with the idea that useful predictions can be made for cases where data is not yet available. Data on isotope exchange reactions, the reactions involving ions of the same element, and reactions of the actinide elements with various anions and cations are considered. (auth)

Separation Procedures

Refer also to abstracts 14812 and 14813.

14668 A/CONF.15/P/496

Dow Chemical Co. Western Div., Pittsburg, Calif.

RECOVERY OF URANIUM FROM ORES BY DIRECT LEACHING WITH ORGANIC SOLVENTS. J. E. Magner and R. H. Bailes. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The process described is the only one which involves lower acid consumption than an aqueous leach. The extractant used is a commercially available mixture of mono- and dioctyl esters of phosphoric acid diluted with a volatile solvent such as methylethyl ketone or hexone. It is essential that some mineral acid be added either to the solvent before contact with the ore or to the slurry of organic extractant and ore. For this use sulfuric acid was found to be superior to other mineral acids. The extracted uranium is stripped from the solvent by contact with hydrochloric acid as in the liquid-liquid extraction process. This process is not applicable to all types of ores. It works well with secondary (oxidized) ores but removes only part of the uranium from primary ores. (J.E.D.)

14669 A/CONF.15/P/497

Dow Chemical Co. Western Div., Pittsburg, Calif.

ENTRAINMENT STUDIES ON SOLVENT EXTRACTION OF URANIUM FROM HEAVY SLURRIES. D. A. Ellis, R. S. Long, and J. B. Byrne. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A study was made of entrainment and of the design of contacting equipment to minimize losses. Solvent extraction processes can be operated in mixer-settler systems, pump mixers, internal mixer-settlers, pulse columns, or centrifugal contactors. Since the internal mixer-settler gives the lowest entrainment of solvent in heavy slurries, a laboratory unit of this type was used in making entrainment studies. Part of the solvent entrained in a slurry can be recovered by dilution with water. Addition of a surface-active agent to slurry-containing, entrained solvent has a deleterious effect, but addition of agents to slurry before contact with solvent is effective in reducing the subsequent entrainment. In general, entrainment is decreased with hydrophilic agents but is increased with hydrophobic agents. This effect is probably related to charges in solid-liquid contact angles. The more effective agents found were all organic sulfonates. (auth)

14670 A/CONF.15/P/499

Columbia Univ., New York and Trinity Coll., Hartford, Conn.

FLOCCULATION, SUBSIDENCE AND FILTRATION OF URANIFEROUS COLLOIDAL ORE DISPERSIONS (SLIMES). Victor K. La Mer and R. H. Smellie, Jr. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An exhaustive investigation of these properties for slimes of various types of uraniferous ores has been

made over the past six years. From these studies, a general theory for the flocculation of suspended fine particles and colloidal dispersions by natural and synthetic polymeric flocculants was developed. Methods were developed which give highly reproducible and quantitative data of subsidence and filtration rates which are of general applicability in chemical engineering and mineral technology. Quantitative correlations among the adsorption of flocculants, specific surface areas of particles, and rates of filtration were developed and tested. These relationships are valid for the slimes prepared from a variety of natural ores and pure chemical compounds. It is possible to predict the optimum subsidence and filtration rates as dependent upon the nature and concentration of the flocculant as well as the chemical composition of the solid particles in the slimes. (auth)

14671 A/CONF.15/P/500
Uranium Reduction Co., Moab, Utah.
OPERATION OF THE RESIN-IN-PULP URANIUM PROCESSING MILL AT MOAB, UTAH. L. A. Painter and T. F. Izzo. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Information on the crushing, grinding, leaching, sand-slime separation, resin-in-pulp, precipitation, filtration, and drying operations of the resin-in-pulp processing mill at Moab, Utah, is presented. The equipment application and problems peculiar to the RIP process are presented. Discussed extensively are the metallurgical and mechanical aspects of the RIP and sand-slime separation sections of the mill. Various changes in equipment and unit processes were necessary after start-up due to both the difficulties in scaling from pilot to full-scale operations with no similar existing full-scale plant and to radical changes in the character of the ores treated. (auth)

14672 A/CONF.15/P/501
Bureau of Mines, Salt Lake City.
SOLVENT EXTRACTION FOR RECOVERING URANIUM AND VANADIUM FROM SALT-ROAST-PROCESS SOLUTIONS. J. B. Rosenbaum, S. R. Borrowman, and J. B. Clemmer. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A procedure has been developed for simultaneous recovery of uranium and vanadium from sulfuric acid leach solutions of salt roast calcines. A combination of alkylamines and organophosphates in a kerosene solution will selectively extract uranium and vanadium from sulfate solutions grossly contaminated by chlorides, aluminum, and ferric iron. The mixed extractants give better results than amines or organophosphates when used independently. The loaded amone-organophosphate can be stripped with sodium carbonate to give a concentrated solution of the uranium and vanadium suitable for processing by conventional procedures to separately recover the uranium and vanadium. Alternatively, the loaded organic can be stripped with sodium hydroxide to give a sodium diuranate product and a solution of sodium vanadate. The paper presents results of batch and continuous tests on typical salt roast leach solutions to investigate the factors influencing separation and recovery of specification-grade uranium and vanadium products. (auth)

14673 A/CONF.15/P/502
Ionics, Inc., Cambridge, Mass.
APPLICATION OF ION TRANSFER MEMBRANES IN NUCLEAR CHEMICAL PROCESSING. E. A. Mason and E. J. Parsi. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A broad review of the properties of membranes and their variety of potential applications in nuclear chemical processing is presented. The properties of ion transfer membranes which are important in determining the selection and application of membranes to various processes are summarized, and a series of brief descriptions (including data) of applications in nuclear processing which have already been subject to investigation are presented. In ion transfer membranes, ion "exchange" in the more conventional sense does not occur, and so chemical regeneration is not required. Descriptions of chemical structures along with data on the electrical resistance, transport efficiencies, and water transfer are included. Stabilities of various membrane types in a variety of chemical solutions found in the nuclear industry and to beta and gamma irradiation are discussed. Examples of applications are: (1) in the recovery and concentration of hydrofluoric acid from a waste stream, (2) concentration of lithium and sodium hydroxide solutions, (3) conversion of lithium and sodium chlorides and sulfates to the corresponding hydroxides, (4) preparation of acid deficient solutions of aluminum, thorium, and uranium nitrates, (5) separation of light and heavy water and of potassium and ammonium ions (as typical of the separation of like cations), (6) removal of nitric acid, and aluminum nitrate from radioactive waste solutions, (7) and in the electrolytic reduction of uranyl solutions in the production of uranium tetrafluoride. (auth)

14674 A/CONF.15/P/504
National Lead Co., Inc. Raw Materials Development Lab., Winchester, Mass.
THE CUPRIC AMMONIUM REAGENT AS AN OXIDANT IN THE CARBONATE LEACHING OF URANIFEROUS ORES. M. A. DeSesa, P. J. Magno, H. E. Gardner, and E. Dickerman. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A variety of chemicals were tested for their efficiency as oxidants to promote the dissolution of uranium dioxide in a solution 0.5M in sodium carbonate and 0.5M in sodium bicarbonate. This study indicated several oxidants were as efficient as, or superior to, potassium permanganate because the initial high rate of dissolution with permanganate was decreased by the formation of a coating of manganese dioxide on the surface of the uranium dioxide particles. It was demonstrated that use of the cupric ammonium reagent as oxidant in atmospheric pressure carbonate leaches results in higher uranium extractions in a shorter time and at less cost than when potassium permanganate is used as oxidant. Also, it was shown that in autoclave pressure leaching the same extraction can be obtained in a much shorter time when the cupric ammonium oxidant is used as compared to the rate of extraction without an added oxidant. The success of the laboratory and pilot plant tests has resulted in a test of the cupric ammonium reagent at the Monticello mill. Initial results are very encouraging, e.g., the average residue dropped from 0.034 to 0.017% U_3O_8 when cupric ammonium oxidant was substituted for potassium permanganate. Further plant scale tests are now in progress. (auth)

14675 A/CONF.15/P/505
National Lead Co., Inc. Raw Materials Development Lab., Winchester, Mass.
KINETICS OF THE DISSOLUTION OF URANIUM

DIOXIDE IN CARBONATE–BICARBONATE SOLUTIONS. W. E. Schortmann and M. A. DeSesa. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A conference version of WIN-89.

The kinetics of the dissolution of uranium dioxide in sodium carbonate–sodium bicarbonate solution were determined in a study aimed at obtaining fundamental information about the carbonate process for leaching uranium from its ores. A rate equation incorporating the effects of surface area, oxygen partial pressure, temperature, and reagent concentrations was developed, and a mechanism consisting of two consecutive reactions at steady state was proposed as follows: the oxidation of the reduced uranium to U(VI) and the subsequent formation of uranyl dicarbonate by the reaction of the hexavalent uranium oxide surface with either the carbonate or bicarbonate ions. The rate of oxidation is probably governed by the rate of dissociation of adsorbed oxygen, and the conversion of the uranyl dicarbonate to uranyl tricarbonate proceeds very rapidly. A rate equation was derived, and a value for the activation energy of the second reaction was calculated and found to be in agreement with the activation energy for the carbonate dissolution of uranium trioxide (about 20 kcal per mole uranium) which indicates that this reaction, as well as the oxidation, is chemical rather than diffusional in nature. (J.R.D.)

14676 A/CONF.15/P/506

Oak Ridge National Lab., Tenn.

THE EXCER PROCESS–AN AQUEOUS METHOD FOR PRODUCTION OF PURE URANIUM TETRAFLUORIDE FROM CRUDE URANIUM SOURCES. I. R. Higgins, W. J. Neill, and L. E. McNeese. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An aqueous method of preparing pure UF_4 from ore leach liquors by ion exchange and electrical or chemical reduction is presented. The process may be adapted to a variety of crude uranium sources, such as concentrates and irradiated fuel or metal scrap solutions as well as ore leach liquors. The uranium is separated from the bulk of the anions by an anion exchange resin, and cation resins are used to eliminate all but the desired anionic species. The partially purified uranyl salt is reduced in a continuous electrolytic cell, or with iron, to uranous ion, and the hydrated green salt ($UF_4 \cdot \frac{3}{4} H_2O$) is precipitated by addition of hydrofluoric acid. The wet green salt is dried to a free-flowing powder and is then ready for bomb reduction. (J.R.D.)

14677 A/CONF.15/P/509

Oak Ridge National Lab., Tenn.

SOLVENT EXTRACTION PROCESSING OF URANIUM AND THORIUM ORES. K. B. Brown, C. F. Coleman, D. J. Crouse, C. A. Blake, and A. D. Ryon. 41p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Amex and Dapex processes are described. Flow diagrams for application to uranium recovery are presented and are discussed with regard to chemical reactions involved, effects of process variables, factors affecting the choice of extraction reagent, process equipment, and estimated process costs. Pertinent chemical and operational differences between the two processes are pointed out, and the status of their commercial application is given. The two processes serve to complement each other in providing efficient processes for a wide range of ore leach liquor compositions. By appropriate choice of extractant and operating conditions, the Amex process can be adapted to the recovery of thorium and possibly vanadium, and the Dapex process can be adapted to the recovery of vanadium. The latter process has been commercially installed in two ore processing plants. Representative flow diagrams for vanadium and thorium recovery are presented along with brief discussions of the important process variables. In addition to the recovery of uranium, thorium, and vanadium, the properties of the various reagents utilized in these processes give cause for considering other applications. The processes described, important in themselves, are also important in demonstrating the feasibility of a new technology wherein the ion exchange principle is utilized on a solvent extraction basis. The wide range of control available through choice of reagent structure and diluent type and the inherent advantages of liquid-liquid techniques combine to offer a highly versatile operation which may find application in other inorganic and organic separations. Current development of applications in radiochemical processing is briefly described. (auth)

14678 A/CONF.15/P/510

Oak Ridge National Lab., Tenn.

AMINE SALTS AS SOLVENT EXTRACTION REAGENTS FOR URANIUM AND OTHER METALS. C. F. Coleman, K. B. Brown, J. G. Moore, and K. A. Allen. 21p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Extractions with organic solutions of high molecular weight alkylammonium salts can be described in terms of ion exchange equilibria, in close parallel to sorption by anion exchange resins. At the same time there are significant differences between the liquid and the resinous extractants, important to process, analytical, and physicochemical applications. A major advantage of the amine solutions, in addition to certain inherent advantages of liquid over solid and of disperse over polymerized reagents, lies in the wide variations of extraction power and selectivity available through choice of reagent structure and diluent. The versatility of this controlled extraction behavior is described in terms of extraction of acids, extractions of uranium(VI) from sulfate solutions, selectivity (i.e., relative extractions of various metal ions) from sulfate solutions, and extractions of several types of metal ions from different aqueous systems. (auth)

14679 A/CONF.15/P/511

Vitro Engineering Co., New York, and Vitro Uranium Co., Salt Lake City.

DESIGN AND OPERATION OF A URANIUM PROCESSING MILL USING LIQUID ION EXCHANGE (SOLVENT EXTRACTION). Kathleen M. Black, Joseph Koslov, and James D. Moore. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

During the past year the Vitro Uranium Company uranium mill at Salt Lake City underwent extensive alterations designed to improve over-all milling flexibility and efficiency. Included were design and construction of (1) a 1,000 tons per day mine run ore sampling plant, (2) a second ball mill-classifier grinding circuit, and (3) a recovery plant designed to utilize the newly developed liquid-liquid extraction process. Those factors, including economics and ore supply, which influenced decisions to make the changes are discussed. The ore supply situation available for this milling facility indicated certain additional flexibility should be pro-

vided from the standpoint of both cost and types available. AEC contract requirements and sampling economics are discussed with regard to construction of this unit. Extensive pilot plant investigations are reported for a liquid-liquid extraction process using 3% dodecyl phosphoric acid-kerosene solvent. Pertinent solvent chemistry is discussed and the physical and chemical data governing the extraction process are shown. Uranium values, as uranyl ion, UO^{2+}, are extracted from the sulfuric acid leach solutions into a kerosene solution of dodecyl phosphoric acid and stripped from the organic phase by concentrated hydrochloric acid. The resulting uranyl chloridehydrochloric acid solution is evaporated to recover the hydrochloric acid, and the evaporator bottoms are neutralized with ammonia to precipitate ammonium diuranate, which is calcined to U_3O_8. The new solvent extraction section design is presented from a process engineering design standpoint. Existing portions of the Vitro Uranium Company plant such as ore receiving, storage, size reduction, and leaching are also described. A flowsheet for the solvent extraction process is included and each of the process steps is described in detail. The major operating and design variables are discussed and significant design values are tabulated. Description of extensive application of plastics and various other materials of construction is included. Special materials used in pump and instrument construction are discussed with regard to service under extremely corrosive conditions. A unique, high capacity turbine mixer for liquid-liquid contacting is described. A summary and breakdown of the capital costs are included. (auth)

14680 A/CONF.15/P/512

National Lead Co., Inc., Grand Junction, Colo.

PILOT PLANT ALKALINE LEACHING OF URANIUM ORES. R. G. Beverly and W. D. Charles. 12p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The results from pilot plant tests using open agitated tanks, open Pachuca tanks, pressurized Pachucas, and a 1200-gallon autoclave are described. Various types of leach vessels were tested. Other variables studied were leaching time, temperature, and pressure, sodium carbonate and bicarbonate concentration, methods and degree of agitation, fineness of ore grind, pulp density, oxygen adsorption, and various oxidants including $KMnO_4$, Cu-NH_3, and air. The effect of certain variables on filtration rates of the residue after leaching and on precipitation of the uranium bearing liquor are also reported. The paper concludes that the alkaline leach process can be used to recover uranium from a wide variety of ores and that by proper control of process variables, uranium dissolution in the range of 94 to 97% can be expected. (auth)

14681 A/CONF.15/P/513

Colorado School of Mines Research Foundation, Golden.

PRETREATMENT OF URANIUM ORES. F. T. Davis and Glen E. Hanson. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Treatment of certain uranium ores prior to leaching is often necessary or desirable to ensure optimum metallurgical results. The results of a pretreatment operation may include the following, either singly or in combinations: concentration of the uranium-bearing minerals, removal of undesirable constituents from the ore, separation of mutually deleterious mineral fractions for separate processing, alteration of chemical compositions, or to effect an improvement in the physical handling characteristics of the ore. Flotation is discussed as a possible method of concentration of both primary and secondary ores. Flotation of extraneous materials from uranium-bearing ores is also covered. This includes flotation of iron sulfide minerals to reduce subsequent chemical consumption, flotation of copper sulfide minerals not only to effect a recovery of copper but also to reduce subsequent chemical consumption, flotation of carbonaceous material to improve leaching extraction and succeeding solids-liquid separations, and flotation of carbonate minerals to permit alkaline leaching of the calcareous fraction and acid leaching of the silicious fraction. The possibility of upgrading both primary and secondary ores by attrition grinding followed by classification into sand-slime fractions, including the economic factors involved, is discussed. Roasting to alter the chemical composition of various ore types is also discussed. This includes oxidizing roasting, roasting with additions to the ore, and roasting to improve subsequent handling characteristics. The new processes involving classification of sands and slimes followed by acid leaching of the sand portion and ion exchange recovery of the solubilized uranium from the combined slime portion and pregnant solution from the sand leaching are discussed. The relative economic advantage of the various methods of pretreatment are tabulated. (auth)

14682 A/CONF.15/P/514

Idaho Operations Office, AEC.

NUCLEAR FUEL PROCESSING PLANTS—A SURVEY OF DESIGN AND OPERATIONAL PRACTICES. J. L. Schwennesen. 32p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A detailed survey of plant design philosophy, engineering, and operational control is presented. The discussion includes a comparison of a basic element of plant design, e.g., remote vs. direct maintenance philosophy, structural bases for plant design, equipment fabrication, and aspects of locating supporting facilities. The discussion also includes the evaluation of opinion and experience with respect to use of mechanical equipment, the evaluation of the flexibility factor aimed at ease of future plant additions, and changes in plant operational control philosophy as a result of experience, new processes, or equipment innovations. These factors are integrated with respect to their place in the economic picture for future plants. (J.R.D.)

14683 A/CONF.15/P/515

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

IMPROVED PULSED SOLVENT EXTRACTION COLUMN CARTRIDGE. R. G. Geier. 26p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

It has been demonstrated that improved efficiencies and/or throughputs can be obtained in pulse columns if deviations from equally-spaced, identical stainless steel sieve plates are incorporated into the design of the column internals. Some of the techniques found advantageous in uranium tributyl phosphate in diluent systems include the utilization of: nozzle plates, sieve plates of different geometry and spacing, and sieve plates fabricated from different materials of construction. Test results are delineated and compared with those from other studies. The influence of plate geometry on the effects produced by mixing metal and plastic sieve plates is discussed. (auth)

14684 A/CONF.15/P/516

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

OPERATING EXPERIENCE IN A "HOT" SOLVENT EXTRACTION PILOT PLANT. G. C. Oberg and R. J. Sloat. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The operating experience gained in the "hot" pilot plant constructed at Hanford to evaluate solvent-extraction processes is discussed. After enumeration of the difficulties encountered, design concepts are presented which should be incorporated in new pilot plants to minimize operating and maintenance difficulties in a pilot plant employing a contact maintenance philosophy. During actual pilot plant operation, it was necessary to decontaminate the plant frequently to permit "contact" maintenance. The decontaminating solutions used and their specific applications for various types of radioactivity, and special decontaminating devices and techniques developed for removing surface contamination are discussed. (auth)

14685 A/CONF.15/P/518

Du Pont de Nemours (E.I.) & Co. Savannah River Lab., Augusta, Ga.

CRITICALLY SAFE EQUIPMENT FOR AQUEOUS SEPARATIONS PROCESSES. T. J. Colven. 13p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The operating characteristics of critically-safe "slab" mixer-settlers and continuous solvent washers are described. The effectiveness of some experimental units of each type was evaluated for a number of tributyl phosphate-kerosene and uranyl nitrate-nitric acid-aluminum nitrate systems. The units described are prototypes of equipment that could be used in a full scale solvent extraction plant. The mixer-settlers are of the "pump-mix" type and are shaped in the form of slabs, three inches high. When positioned in an operating area so that the large faces of the slab are at least six feet away from solid reflectors, the slabs are critically safe for concentrations of fissionable materials as high as 400 grams per liter of solution. The critically-safe solvent washers are cylinders, 7 inches in diameter and 12 feet high. A continuous washer was evaluated with 6 and 30% tributyl phosphate in kerosene solutions. The effect of mixing speed, recirculation rate, cylinder height, and solution properties on the entrainment of a sodium carbonate wash in the solvent was determined at processing rates up to 0.5 gpm. A unitized equipment layout in which continuous washers are coupled directly to two mixer-settlers in such a way as to provide a closed solvent circuit is presented to illustrate a practical solvent extraction cycle with a minimum of equipment and solvent inventory. (auth)

14686 A/CONF.15/P/519

Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Augusta, Ga.

TEMPERATURE EFFECTS ON TBP SOLVENT EXTRACTION PROCESSES. D. G. Karraker. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

TBP extracts uranium (VI) and plutonium (IV) well, and most of the fission products poorly. Ruthenium, zirconium, and niobium are the most difficult fission products to separate, and the radioactivity of the end products is determined by the extent to which these fission products are eliminated. The general behavior of these fission products indicates that slow changes among their species restrict their separation. An increase in temperature accelerates changes among these species, and results in an increased fission product separation for TBP processes. A combination of adsorption processes for removal of residual fission products with the improved, high temperature, Purex process achieves decontamination factors greater than 5×10^8 for the uranium product and greater than 5×10^7 for the plutonium product. This performance equals the decontamination achieved in the normal Purex process (two or three solvent extraction cycles), with a considerable reduction in the required equipment. The decontamination of both cycles of the 25 process was improved by operation at 70°C. The ruthenium decontamination of the first cycle was a factor of 100 greater at 70°C than at 30°C, and the decontamination for zirconium-niobium (combined) was improved by a factor of ten. The improvement in the second cycle decontamination varied with first cycle performance, and apparently was mainly limited by the activity present in the feed. Samples of the organic phase from the extraction-scrub contactor of the first cycle showed that the same amount of activity was extracted at both temperatures; but the extracted activity was removed much faster at higher temperatures. The radiolysis of TBP by the radioactivity of the feed solution was observed in experimental work on the 25 process. The results indicated that the radiolytic product, dibutylphosphate, impairs decontamination. These results were obtained with miniature solvent extraction equipment, operated continuously for extended periods, and processing feed solutions prepared from irradiated material. (auth)

14687 A/CONF.15/P/520

Du Pont de Nemours (E.I.) & Co. Savannah River Lab., Augusta, Ga.

CONCENTRATION AND PURIFICATION OF URANIUM, PLUTONIUM, AND NEPTUNIUM BY ION EXCHANGE IN NUCLEARLY SAFE EQUIPMENT. F. W. Tober. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The initial products from the processing of irradiated fuel elements are usually relatively dilute solutions of uranium, plutonium, or neptunium which must be concentrated and further purified. Ion exchange has proved to be a useful method for accomplishing these objectives. Several isotopes which are, or accidentally could be, present in the process streams are fissionable. All the equipment, therefore, must be designed to prevent the accumulation of fissionable material which could generate an excessive amount of neutrons by multiplication. Even with the limitations imposed to provide nuclear safety, the processing can be done economically by ion exchange because a large batch of product can be absorbed, purified, and eluted within a short period of time. Nuclear safety is easily obtained by using resin beds with small diameters, or by using a composite column that consists of a series of shallow beds separated sufficiently to avoid interaction of the neutrons from the individually safe beds. Rapid processing is obtained by using the maximum flowrates that are practical. The rates of processing are directly proportional to the cross-sectional area but are independent of the depth of resin in the ion exchange column. General requirements that are common to all the processes are discussed, together with separate discussions of processes for uranium, plutonium, and neptunium. Typical chemical

flowsheets are presented. The process data needed to develop ion exchange processes and the basic chemistry that illustrates specific problems are described. (auth)

14688 A/CONF.15/P/521
Du Pont de Nemours (E. I.) & Co. [Savannah River Lab., Augusta, Ga.].
A RATIONALE FOR THE RECOVERY OF IRRADIATED URANIUM AND THORIUM BY SOLVENT EXTRACTION. T. H. Siddall, III. 24p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Some of the calculations which can be made to predict the proper operating conditions for multistage contractors in which tri-n-butyl phosphate is the extractant are given. The calculations are made from the results of equilibrations in single stages in the laboratory. Tri-n-butyl phosphate is compared with other trialkyl phosphates and with certain dialkyl alkylphosphonates. The basis of the comparison is the method of calculation that was developed. (A.C.)

14689 A/CONF.15/P/526
Phillips Petroleum Co., Atomic Energy Div. Idaho Falls, Idaho.
ZIRCONIUM ALLOY FUEL REPROCESSING. D. G. Reid, C. E. Stevenson, R. B. Lemon, and F. K. Wrigley. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The fuel elements are dissolved in hydrofluoric acid and the resulting solution adjusted with aluminum nitrate to a composition suitable for solvent extraction in stainless steel equipment. Three solvent extraction cycles are used to separate the uranium from the zirconium, fission products, and transuranic elements. Uranium recovery efficiency is better than 99.5%, and decontamination factors greater than 10^6 are realized over the three extraction cycles. It is indicated that processing costs for 1% U–Zr fuel could be reduced to about $1.75/g of uranium for a unit capable of processing 7.5 kg uranium per day. (W.D.M.)

14690 A/CONF.15/P/535
Oak Ridge National Lab., Tenn.
RECOVERY OF URANIUM FROM HIGHLY IRRADIATED REACTOR FUEL BY A FUSED SALT—FLUORIDE VOLATILITY PROCESS. G. I. Cathers, W. H. Carr, R. B. Lindauer, R. P. Milford, and M. E. Whatley. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A fused-salt fluoride volatility process is being developed at Oak Ridge National Laboratory for recovering uranium from either molten fluoride salt fuel or zirconium–uranium heterogeneous reactor fuel. The basic step in the process is conversion of the uranium to UF_6 with F_2 in a fluoride salt melt with volatilization of the UF_6 from the melt. In the case of the zirconium–uranium fuels the fuel element is dissolved in a fluoride salt melt with hydrogen fluoride at 600 to 700°C, which with the molten fluoride fuels the UF_4 is a constituent of the melt. Volatile fission product fluorides are removed from the UF_6 in an absorption-desorption step with a pair of NaF beds, and the decontaminated UF_6 is collected in cold traps. Compared to aqueous processing, the fused salt fluoride volatility process has fewer chemical steps in the over-all uranium fuel cycle, an appreciably lower waste volume, and the probability of a more compact plant. (auth)

14691 A/CONF.15/P/536
Oak Ridge National Lab., Tenn.
OPERATING EXPERIENCE WITH TWO DIRECT-MAINTENANCE RADIOCHEMICAL PILOT PLANTS. F. R. Bruce, E. M. Shank, R. E. Brooksbank, J. R. Parrott, and G. S. Sadowski. 51p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Thorex plant has a capacity of 150 kg of thorium per day, yielding thorium and uranium-233 products suitable for reactor recycle. The Metal Recovery Facility has a capacity of 450 kg of uranium per day and has been used for the processing of a wide variety of irradiated and unirradiated plutonium and uranium. The Thorex Process is applicable to the recovery of uranium and thorium from heterogeneous reactor fuels and from the blanket of the aqueous homogeneous reactor. Operation of the Thorex and Metal Recovery facilities has given information on process performance, cost of construction and operation, and control of radiation exposure to personnel. (J.R.D.)

14692 A/CONF.15/P/537
Oak Ridge National Lab., Tenn.
AMERICIUM AND NEPTUNIUM RECOVERY PROCESSES. W. H. Lewis. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Solvent extraction processes were developed on a pilot plant scale for recovering neptunium-237 and americium-241 from irradiated uranium and fuel cycle wastes. Neptunium was recovered from irradiated normal uranium, irradiated enriched uranium alloyed with aluminum, and fluorination ash produced from the conversion of recovered UO_3 to UF_6. Americium was separated from a fuel cycle waste containing large quantities of lanthanum and cerium. Final purification of both americium and neptunium from solvent extraction processes was achieved by ion exchange. A detailed description of these processes is presented. (J.R.D.)

14693 A/CONF.15/P/544
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
TERTIARY AMINE EXTRACTION OF PLUTONIUM FROM NITRIC ACID SOLUTIONS. A. S. Wilson. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Data are presented to show the effect of pertinent variables on the extraction of plutonium. The extraction of plutonium(III) and (VI) is shown to be small. The data on the extraction of plutonium(IV) by several amines are presented and discussed. Some experiments on the effect of the organic diluent on the solubility of the plutonium(IV)-amine complex are presented. Temperature effects were also investigated and these results are summarized. Some discussion on the probable mechanism responsible for the extraction of plutonium(IV) by tertiary amines is presented. (auth)

14694 A/CONF.15/P/546
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
THE PREPARATION AND REPROCESSING OF PLUTONIUM–ALUMINUM ALLOY. W. L. Lyon. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An alloy of plutonium and aluminum offers an attractive reactor fuel material since the technology of the

matrix is sound, the alloy is readily produced and fabricated, it has good nuclear and physical properties, and it is acceptable with water coolant as regards heat transfer and corrosion rate. The alloy may be produced by direct alloying of the metals, or by reduction of plutonium fluoride or oxide in aluminum. The latter method, wherein PuO_2 and cryolite mixtures are added to molten aluminum, employing the technique of Saller and Runnalls, is expected to find extensive application in the production of fuel loadings for power reactors. The chemical reprocessing of Pu-Al fuel may be accomplished by adapting aqueous methods for which sound technical bases exist. On the other hand, this material may lend itself to processing by one of several interesting pyrochemical schemes. Some of these are described together with brief comments regarding the economics of plutonium fuel processing. (auth)

14695 A/CONF.15/P/697

Bureau of Mines, Albany, Oreg.

SOME DEVELOPMENTS IN THE EXTRACTIVE METALLURGY OF COLUMBIUM (NIOBIUM). M. L. Wright and F. E. Block. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The program at the U. S. Bureau of Mines has involved the extraction and purification of niobium from the complex mineral euxenite, which is native to the United States, and from niobium and tantalum bearing metallurgical slags that result from the smelting of tin in the Belgian Congo. The major problem in recovering niobium involves its separation from tantalum, since these elements are very similar chemically and are almost always associated together. Solvent extraction techniques are adaptable to continuous, large-scale operation and this approach was applied to separating niobium and tantalum. Good separation was achieved by using a feed solution of niobium and tantalum in hydrofluoric and sulfuric acids. When this solution was contacted with methyl isobutyl ketone, both niobium and tantalum were coextracted into the organic extract leaving other metallic impurities in the aqueous raffinate. By back extracting the organic extract with a dilute acid solution, niobium was extracted preferentially. Niobium oxide of greater than 99.9% purity was prepared by this method using stagewise extraction. Purities of over 99.99% were achieved employing multiple extractions. Two procedures were employed to reduce niobium compounds to metal. By reacting niobium pentoxide with metallic calcium in a closed bomb, a fused mass of niobium metal was prepared directly. A method similar to the Kroll process for zirconium was used to prepare niobium sponge. It involved the controlled reaction of gaseous niobium pentachloride with molten magnesium under an inert atmosphere. Byproducts were separated from the sponge metal by volatilization in a vacuum. Metal products from both procedures contained oxygen as the major impurity and required further refining to yield ductile metal. Upon melting in a high vacuum using electron bombardment as a source of heat, soft, ductile niobium was produced. (auth)

14696 A/CONF.15/P/717

Olin Mathieson Chemical Corp., New Haven; Stanford Research Inst., Menlo Park, Calif.; and Sylvania-Corning Nuclear Corp., Bayside, N. Y.

A CONTINUOUS ELECTROLYTIC PROCESS FOR THE PREPARATION OF BERYLLIUM METAL. Robert B. Holden, Milton C. Kells, and Charles I. Whitman. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The continuous production of beryllium metal by low temperature fuel salt electrolysis into a continuous circulating mercury cathode was demonstrated. The electrolyte employed is a 50-50 mol % $NaCl-BeCl_2$ mixture with a melting point under 300°C. The beryllium which deposits in the mercury forms an amalgam which can be removed continuously from the mercury stream by filtration. The amalgam contains about 2% beryllium by weight and can be vacuum hot-pressed directly to beryllium metal; or, alternatively, beryllium powder can be prepared by the distillation of the mercury. (auth)

14697 A/CONF.15/P/719

Oak Ridge Gaseous Diffusion Plant, Tenn.

APPLICABILITY OF A SEPARATION PROCESS FOR LARGE-SCALE ISOTOPE PRODUCTION. S. A. Levin and E. Von Halle. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The considerations, presented in two parts, deal with isotope enrichment by irreversible chemical reactions. In the first part the necessary equations that quantitatively describe the process are developed. The performance of both a single separation state and of a cascade of stages connected in series are considered. The other part of the presentation deals with the design considerations necessary to evaluate a process. The applicability of irreversible chemical reactions to large-scale separation of isotopes is then evaluated by comparing costs for isotope separation in a cascade utilizing in one case irreversible chemical reactions and in the other case chemical exchange. The chemical exchange process was chosen as a standard of comparison because it has so far been the most attractive process in the case of light element. The evaluation shows that the irreversible chemical reaction process is severly handicapped because of its requirements for a reflux after each stage compared to a chemical exchange process which requires refluxing only at the two ends. It therefore appears that for large-scale separation of isotopes the irreversible chemical reaction process will not be competitive unless it has a relatively high separation factor compared with that of the corresponding chemical exchange process. For very small enrichments the costs would be more comparable. (auth)

14698 A/CONF.15/P/723

Virginia. Univ., Charlottesville and Virginia. Univ., Charlottesville. Ordnance Research Lab.

TESTS OF THE THEORY OF ISOTOPE SEPARATION BY CENTRIFUGING. J. W. Beams, L. B. Snoddy, and A. R. Kuhlthau. 20p. $0.50 OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Several experiments designed to test the theory for the separation of isotopes in a centrifuge are described. The separations were carried out primarily with the process material in the gaseous or vapor phase. Most of the separation experiments were made on the isotopes of chlorine in carbon tetrachloride and ethylchloride. The evaporative-centrifuge method and the concurrent centrifuge method were investigated. In each of the experiments the temperature of the centrifuge rotor was held uniform and constant. (auth)

14699 A/CONF.15/P/831

Oak Ridge National Lab., Tenn.

FISSION PRODUCT PILOT PLANT AND OTHER DEVELOPMENTS IN THE RADIOISOTOPE PROGRAM AT THE OAK RIDGE NATIONAL LABORATORY.

E. Lamb, H. E. Seagren, and E. E. Beauchamp. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A survey is given of the plant and process improvements incorporated into the program from 1955 until the present time. A major addition to the production capacity of separated long-lived fission products was made by the completion of the Fission Product Pilot Plant, which has a designed annual capacity of 200,000 curies of Cs^{137}. Comparable amounts of the other fission products, Sr^{90}, Ru^{106}, Ce^{144}, Pm^{147}, and Tc^{99}, will also be separated from aqueous wastes resulting from irradiated uranium recovery processes. Short-lived fission product production has been increased by the addition of equipment in which Zr^{95}-Nb^{95}, Ba^{140}, Nd^{147}, Pr^{143}, Sr^{89}, Ce^{141}, and Ru^{103} are recovered from the uranium solution remaining after the distillation of I^{131}. Other short-lived radioisotopes with half-lives as short as 12.44 hours are produced by processing irradiated material. The radioactive noble gases, Xe^{133} and Kr^{85} have also been made available in greater quantities by the use of improved equipment. In general, radioisotope production has grown from 30,000 curies per year in 1955 to over 120,000 curies at the present time, and in the same period the average shipment has increased from 2,000 to 10,000 mc. (auth)

14700 A/CONF.15/P/832

Oak Ridge National Lab., Tenn.

THE USE OF RADIOISOTOPES FOR THE MEASUREMENT OF INTERFACIAL AREA. J. C. Bresee and C. V. Chester. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A method for direct determination of an interfacial area by measuring the rate of reaction between a radioisotope in one phase and a radiation-sensitive substance in the second phase was developed. It is based on the fact that, if the particle emitted by the radioisotope has a short range, the reaction is restricted to the vicinity of the interface. If the minimum dimensions of the second phase are large compared with the range of the particle, the reaction rate is directly proportional to the interfacial area. To test the radioisotope method experimentally, Po^{210} was the most satisfactory isotope. The experimental system was an aqueous solution of polonium-210 nitrate in contact with a liquid fluorocarbon. The fluorine atoms underwent an α,n reaction at the interface, and boron trifluoride tubes external to the contactor detected neutrons and therefore measured the interfacial area. The proposed method has the advantage of being direct, adaptable to remote operations, and capable of being applied to opaque systems. It has the limitations of being applicable only to two phase systems with extreme immiscibility, requiring materials of construction upon which radioisotope selective deposition or plating will not occur, and imposing stringent requirements on the containment of radioactivity. (auth)

14701 A/CONF.15/P/932

Oak Ridge Gaseous Diffusion Plant, Tenn.

BASIC STUDIES OF THE SEPARATION OF URANIUM HEXAFLUORIDE FROM MIXTURES CONTAINING CHLORINE TRIFLUORIDE AND HYDROGEN FLUORIDE. H. A. Bernhardt, E. J. Barber, W. Davis, Jr., and R. M. McGill. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Processes for the conversion of uranium compounds or uranium metal to uranium hexafluoride ordinarily involve the use of a powerful fluorinating agent. Elemental fluorine is used when the scale of operations justifies the construction of a fluorine generating plant, but for smaller operations the use of the interhalogens of fluorine has definite advantages. These compounds provide a high concentration of fluorinating power at moderate temperatures and pressures and are more easily stored and transported than fluorine. In addition, fluorinations in the liquid phase often proceed more smoothly than those with gaseous fluorine. However, the use of the interhalogens introduces the problem of separating the uranium hexafluoride from the unreacted reagent and from any by-products which may have been formed. The present work is concerned with the determination of the phase equilibria among the materials uranium hexafluoride, chlorine trifluoride, and hydrogen fluoride. This mixture occurs as a result of fluorinating uranium metal with chlorine trifluoride-hydrogen fluoride solutions or as a result of treating many uranium compounds and ores with chlorine trifluoride. These phase equilibria define the physical conditions necessary for separating the components by the processes of crystallization or distillation and have made possible the successful operation of a pilot plant for the direct recovery of uranium hexafluoride from spent metallic uranium fuel elements. (auth)

14702 A/CONF.15/P/1024

Columbia Univ., New York. Mineral Beneficiation Lab.

RECOVERY OF URANIUM FROM CHATTANOOGA SHALE. F. Z. Pollara, N. Levine, J. R. Killelea, R. C. Musa, and M. D. Hassialis. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A variety of methods for the recovery of uranium has been investigated. Hot countercurrent leaching and oxygen-pressure leaching have been found to be effective. High-temperature chlorination, though not worked out, is another possible method of recovery. Countercurrent leaching at solid-to-liquid ratios in the range 0.5:2 with seven refluxing leach stages of one-half hour each and a sulfuric acid feed of 7.1% results in the extraction of 72% of the uranium. The effects of varying the number of stages, the shale to product ratio, the particle size, the time per stage, and the acid feed were investigated. Oxygen-pressure leaching at elevated temperatures and pressure in the range of 150 to 175°C and 100 to 150 psia gave yields of 80% or better. The effects of leaching time, temperature, oxygen pressure, gas bleeding, and the ratio of shale to water and to recycled pregnant liquor were studied. A continuous process demonstration unit was set up and operated at a feed rate of 36 lb of shale per hour. The results thereof confirmed the batch-work data. Pregnant liquors contain only about 47 milligrams per liter of uranium. These were processed by liquid-liquid extraction using 0.05 moles of 6-benzylamino-3,9-diethyltridecane in kerosene. This solvent shows low distribution coefficients for contaminant ions and a very high distribution coefficient for uranium. Consequently it was possible to recover uranium at high aqueous to organic flow ratios. This combined with a high organic to aqueous flow ratio in sodium carbonate stripping made it possible to produce loaded strip solutions containing more than 18 grams per liter of uranium despite the low level uranium in the feed. Chlorination at temperatures in the range of 500 to 800°C with both retorted and roasted shale using a variety of chlorinating agents was investigated. Roasted shale required carbon in the chlorinating

agent and was capable of 85% volatilization of uranium but required one to three hours. Retorted shale reached the same level of recovery in 15 seconds. Iron and aluminum and considerable quantities of potassium were also volatilized. Whereas steady state chloride product streams were produced no steady state recovery system was developed. Such a system based on the passage of the chloride product stream through hot packed columns containing KCl_3-AlCl_3 mixtures resulted in good uranium retention. However, the columns were difficult to control and unstable. (auth)

14703 A/CONF.15/P/1066
Blockson Chemical Co., Joliet, Ill.
RECOVERY OF URANIUM FROM PHOSPHATE ORES. E. M. Stoltz, Jr. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The work of three major phosphate producers currently recovering uranium from phosphate rocks is briefly summarized. (J.E.D.)

14704 A/CONF.15/P/1434
Brookhaven National Lab., Upton, N. Y.
RECENT ADVANCES IN THE CHEMISTRY OF LIQUID METAL FUEL REACTORS. R. H. Wiswall, J. J. Egan, W. S. Ginell, F. T. Miles, and J. R. Powell. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Recent research has clarified the reactions which occur when U-Bi reactor fuel is contacted with fused salt for the purpose of removing certain fission products. Both engineering data and information about the basic chemistry of the systems involved have been obtained. The best process salt is believed to be the ternary eutectic $MgCl_2$-NaCl-KCl, m.p. 396°C. With this, the reaction by which fission products are removed is of the form 3 $MgCl_2$ (in eutectic) + 2 Ce (in Bi) → 3 Mb (in Bi) + 2 $CeCl_3$ (in eutectic), cerium being a typical salt-extractable fission product. The equilibrium distribution of elements between liquid metal and salt phases is uniquely related to the electric potential at the salt-metal interface. This potential can therefore be used, in principle, to monitor and control a practical process for decontamination and adjustment of uranium concentration. An experimental study of the galvanic phenomena encountered in a flowing countercurrent system of liquid metal and electrolyte was undertaken. In the preliminary stages, mercury and aqueous solutions were used instead of bismuth and fused salt. Electrokinetic effects were found to be sufficiently large that they affect the emf measurement and may affect the extraction process itself. (auth)

14705 A/CONF.15/P/1550
Oak Ridge National Lab., Tenn.
SOLVENT EXTRACTION OF URANIUM AND OTHER METALS BY ACIDIC AND NEUTRAL ORGANOPHOSPHORUS COMPOUNDS. C. A. Blake, Jr., C. F. Baes, Jr., K. B. Brown, C. F. Coleman, and J. C. White. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The properties of a number of new organophosphorus reagents are summarized, and their positions in a new solvent extraction technology are discussed. In contrast to the familiar tributyl phosphate (TBP), the applications of which have been limited to highly salted nitrate solutions, several other neutral and acidic or organophosphorus compounds have demonstrated the ability to extract uranium from a wide variety of aqueous solutions. Some of these reagents have reached commercial use in recovery of uranium from sulfate and phosphate liquors. More generally, by proper choice of reagent it is now possible to extract uranium from nearly any solution in which it is encountered. In addition, many of these reagents show potentiality for extraction of other metals, including vanadium, thorium, zirconium, hafnium, titanium, molybdenum, rare earths, and plutonium, and for separations of closely related elements, including zirconium–hafnium, lanthanides, and actinides. Besides process applications, these extractants offer valuable analytical and physicochemical applications, some of which have already been developed. In addition to the comparisons of different reagent types, correlations with other properties and the effects of variation of structure within a reagent type are also discussed. These include both general and specific effects on extraction power, selectivity, and physical behavior, which are of sufficient magnitude to add significantly to the versatility of this wide range of solvent extraction reagents. (auth)

14706 A/CONF.15/P/1552
Argonne National Lab., Lemont, Ill.
PRODUCTION OF REFINED UF_6 FROM ORE CONCENTRATES BY FLUIDIZATION AND FRACTIONAL DISTILLATION TECHNIQUES. S. Lawroski, A. A. Jonke, N. Levitz, E. J. Petkus, A. H. F. Litty, W. A. Rodger, G. J. Vogel, R. K. Steunenberg, O. Sandus, W. J. Mecham, R. C. Liimatainen, R. W. Kessie, L. Trevorrow, and R. C. Vogel. 29p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A process for the production of gaseous diffusion grade UF_6 involving conversion of uranium ore concentrates to impure UF_6 which is purified by fractional distillation is presented. The use of a fluidized-bed technique is a desirable method for production of the crude green salt, and methods of impurity removal were found. UF_6 can be produced by the fluorination of UF_4 in a fluidized bed reactor with excess fluorine at temperatures from 300 to 600°C. Fractional distillations were made of UF_6 from fluidized bed fluorinations, and operating conditions and product purifications are reported for the grades of feed materials tested. (J.R.D.)

14707 A/CONF.15/P/1795
Argonne National Lab., Lemont, Ill.
DEVELOPMENTS IN PYROMETALLURGICAL PROCESSING. J. H. Schraidt and M. Levenson. 13p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The results of recent work on pyrometallurgical methods and on the problems and status of application to actual reactors as a basic part of the reactor fuel cycle are presented. Information on melt refining includes the progress made on oxide drossing of short-cooled uranium and the melt refining of plutonium-rich alloys. This information also includes the fates of short-lived fission products, which have only recently been determined. The status of extraction processes is presented for blanket processing by liquid magnesium extraction of plutonium and for uranium–bismuth fuel purification by fused salt extraction. Considerable new information has been obtained on fractional crystallization methods. This has resulted from studies on recovery of fertile and fissile elements from reactor core and blanket materials by low melting metal solvents such as zinc, magnesium, and mercury. (auth)

14708 A/CONF.15/P/1830
Los Alamos Scientific Lab., N. Mex.
RECENT DEVELOPMENTS IN PLUTONIUM PROCESSING IN THE UNITED STATES. R. D. Baker and J. A. Leary. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Recent developments in various fields of plutonium processing are discussed. Aqueous and pyrometallurgical processing methods are considered. (W.D.M.)

14709 A/CONF.15/P/1832
Oak Ridge National Lab., Tenn.
ION EXCHANGE PROPERTIES OF HYDROUS OXIDES. K. A. Kraus, H. O. Phillips, T. A. Carlson, and J. S. Johnson. 29p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The large class of amorphous insoluble hydrous oxides has interesting ion exchange properties. These materials have high capacities and suitable exchange rates and may therefore be used in packed columns in typical chromatographic (ion exchange) manner. Hydrous oxides may exhibit either cation exchange or anion exchange properties, or both. The type of adsorption depends on the element on which the oxide is based, on the acidity of the medium and, to some extent, on the ion adsorbed. Though some of the most acidic oxides are soluble (e.g., P_2O_5) or easily dispersible (e.g., MoO_3, WO_3) their intrinsic cation exchange properties may be utilized by incorporating them in excess into an insoluble matrix, i.e., by preparing certain insoluble acidic salts. Some of the materials with cation exchange properties may be used even with extremely small columns for the separation of the alkali metals from each other or of the alkaline earths. The specificity of these compounds for cesium in acidic solutions permits the almost unique isolation of this element from practically all others. Those oxides with anion exchange properties also have unusual selectivities compared with the organic ion exchangers. Oxides based on Bi(III) have high selectivities for the heavier halides and others, such as the oxides of Zr(IV), Nb(V), and Ta(V) for remarkable selectivities for fluorides. (auth)

14710 A/CONF.15/P/1883
California. Univ., Livermore. Radiation Lab.
THE PRODUCTION AND CHEMICAL ISOLATION OF CURIUM^{242} IN THOUSAND-CURIE QUANTITIES. Gary H. Higgins and William W. T. Crane. 14p. (UCRL-5021). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An integrated system of process equipment and chemical separations was designed which would isolate gram quantities of curium while fulfilling four objectives: (1) that the curium be free of gross chemical and fission product impurities, (2) that the product yield would be high, (3) that personnel exposure would be low, and (4) that the process equipment would be replaceable and repairable during operation. The chemical process adopted consisted of combinations of ion exchange separations, thereby avoiding precipitation chemistry. The ion exchange columns were designed to accommodate the high radiation and thermal effects of the adsorbed curium radioactivity. A satisfactory mechanical arrangement was achieved with a "double confinement" system. The chemical apparatus, consisting of a series of closed glass vessels and glass ion exchange columns connected with polyethylene tubing, accomplished the first confinement. This apparatus, along with the associated equipment such as pumps, heat exchangers and off-gas scrubbers, was further enclosed in a "cell box" constructed of glass cloth and fiber impregnated with polyester resin. All four objectives of design were accomplished, but several specific items are being improved. 3,000 to 4,000 curies of curium^{242} were separated from 400 g of iron and aluminum, and from about 500 curies of fission product activity with a chemical yield >80%. Without extensive modification, this equipment could be used to process other highly radioactive substances. (auth)

14711 A/CONF.15/P/1915
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
APPLICATION OF ANION EXCHANGE TO THE REPROCESSING OF PLUTONIUM. J. L. Ryan and E. J. Wheelwright. 21p. $0.50(OTS).

Prepared for the Second U. N International Conference on the Peaceful Uses of Atomic Energy, 1958.

It has been demonstrated that plutonium (IV) can be absorbed from nitric acid solution by anion exchange resins. Anion exchange offers a marked advantage over cation exchange for plutonium processing because of the ease of decontaminating the plutonium from all normally encountered impurities. Anion exchange has been applied as a primary method for the separation of plutonium from irradiated uranium, but processing rates and product concentrations were low. By operating at elevated temperature (50 to 60°C) and by proper choice of anion exchange resins, throughputs may be increased considerably, product concentration is increased, decontamination improved, and the use of reagents other than nitric acid eliminated. Absorption and elution flow rates as high as 80 mg Pu/min, cm^2, decontamination factors of greater than 5×10^3 for fission products and greater than 5×10^4 for uranium and other metallic impurities, and product concentrations of above 50 g Pu/l are readily attainable in a single anion exchange cycle under proper operating conditions. The method is both chemically and mechanically simple. Other processing applications for which anion exchange is particularly appropriate are discussed. (auth)

14712 A/CONF.15/P/1930
Oak Ridge National Lab., Tenn.
DISSOLUTION AND FEED PREPARATION FOR AQUEOUS RADIOCHEMICAL SEPARATION PROCESSES. F. L. Culler and R. E. Blanco. 85p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Most irradiated power reactor fuels can be radiochemically processed by the well established solvent extraction methods provided that the corrosion resistant cladding materials can be removed or dissolved and that the fuel element cores can be dissolved in or converted to an aqueous solution highly salted with nitrate anions. Thus, the aim of much of the current aqueous processing development is to devise compatible mechanical and chemical dissolution procedures for all power reactor fuels. Mechanical processing is being studied as an alternate to non-nitric-acid head-end systems to facilitate associated waste storage and corrosion problems. Mechanical operations include disassembly of complex fuel bundles and dejacketing of fuel rods and pins to expose nitric acid soluble cores. Mechanical techniques under study include chopping, roll decladding, sawing, and breaking. Chemical removal of zirconium cladding can be done with aqueous ammonium fluoride, hydrofluoric acid, sulfuric acid, or by anhydrous hydrochlorination or chlorination in

gas-solid or anhydrous organic media. Stainless steel may be declad by dissolution in sulfuric acid. (auth)

14713 A/CONF.15/P/2388
Argonne National Lab., Lemont, Ill.
FLUORIDE VOLATILITY PROCESSES FOR SPENT REACTOR FUELS. (A Survey of Recent Work in the United States.) R. K. Steunenberg, and R. C. Vogel. 29p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Work has continued at various sites on the development of uranium hexafluoride distillation processes for the recovery of fissionable values from spent reactor fuels. Metallic uranium fuels can be dissolved in bromine trifluoride or chlorine trifluoride, producing uranium hexafluoride. The hexafluoride is purified and decontaminated by fractional distillation. In an advanced version of this process, plutonium in the fuel is also converted to the hexafluoride which is purified by volatilization then decomposed to a nonvolatile product. The application of fluoride volatility processes to various irradiated reactor fuel alloys is considered and possible approaches are indicated. At Oak Ridge National Laboratory the current emphasis is on fused salt processes. Work at Argonne National Laboratory includes the bromine trifluoride process, fused salt studies and investigations on plutonium fluorides. (auth)

14714 A/CONF.15/P/2409
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
AQUEOUS PROCESSES FOR SEPARATION AND DECONTAMINATION OF IRRADIATED FUELS. V. R. Cooper and M. T. Walling, Jr. 68p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A review of recent developments and improvements in aqueous processes for accomplishing separation and decontamination of irradiated fuels from power reactors is presented. Research and development is currently being pursued in the United States on three distinct types of fuel processing methods; pyrometallurgical processes, fluoride volatility processes, and aqueous processes. Although the ultimate role of these processing methods in a nuclear power economy cannot be accurately assessed at the present time, it is felt that the proven reliability and versatility of aqueous processes guarantees them a prominent role in power reactor fuel reprocessing. Aqueous solvent extraction processes, for example, are ideally suited for installation in central processing plants which are designed to handle fuels from a number of power reactors generating a total of several thousand megawatts or more of power. Under these circumstances, nuclear fuels can be processed by continuous processes at high throughputs and at high on-stream efficiency and therefore at low unit cost. (auth)

14715 A/CONF.15/P/2429
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
THE ZIRFLEX PROCESS. J. L. Swanson. 20p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Zirflex Process is designed to accomplish selective dissolution of zirconium or Zircaloy fuel cladding. The process involves the dissolution of the cladding material in solutions of ammonium fluoride alone or in mixture with ammonium nitrate. Mixtures of ammonium fluoride and ammonium nitrate are preferred since they result in very little evolution of hydrogen during the dissolution. One of the main advantages to the process is that these solutions attack austenitic stainless steels only slowly, in sharp contrast to the media (e.g., hydrofluoric acid or hydrofluoric-nitric acid mixtures) generally used for dissolving zirconium. In boiling 6 M NH_4F, the rate of penetration of Zircaloy-2 is nearly 100 mils/hr, while that of typical austenitic stainless steels is only about 0.5 mil/month. (auth)

Syntheses

14716 A/CONF.15/P/824
American Cyanamid Co. Stamford Labs., Stamford, Conn.
THE INITIATOR OF FREE RADICAL ADDITION REACTIONS BY IONIZING RADIATION. R. L. Webb. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Quantitative chemical change occurs in certain organic systems after irradiation. One type of such change is known as free radical addition reaction. Ionizing radiation was described as a means of initiating addition reactions for more than 400 different reagent-substrate pairs, and this method appears to be competitive with other radical forming techniques for industrial scale synthesis if certain dose rate problems can be solved. To compensate for the capital investment required, ionizing radiation offers a number of advantages as an initiator, including radical formation in any system, external control, reaction initiation at low temperatures, and freedom of product contamination by residual chemical initiator or its decomposition products. (J.R.D.)

Tracer Applications

14717 A/CONF.15/P/798
Kansas. Univ., Lawrence.
NEW METHODS FOR PRODUCTION OF RADIOISOTOPE LABELED COMPOUNDS. F. S. Rowland. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A review of new techniques, and a comparison of their practical merits with those of older methods is presented. Classical chemical synthesis and biosynthesis using isotopically labeled materials have some important advantages. With chemical synthesis tracer compounds of high specific activity can be made with good control over the intramolecular position occupied by the isotopic atoms. Standard microsynthetic procedures may be used if they do not induce undesirable exchange reactions. All compounds which cannot be synthesized may be biosynthesized in living organisms, although only at low specific activities. The chief disadvantage of these classical methods is the length and complexity of the procedures generally required. The recently developed techniques seek to avoid this by using the inactive form of the tagged compound desired and directly exchanging into it the labeling isotope. In recoil labeling the kinetic energy required to introduce the radioisotope into the compound is supplied by the recoil of the nuclear process forming the isotope. To label an organic compound with tritium it is mixed with a lithium salt and neutron-irradiated. High-energy tritium from the $Li^6(n,\alpha)T$ reaction ejects and replaces hydrogen atoms in the

compound. Moderate specific activity of all but the most complex molecules are thus obtainable. Methods for C^{14} are similar. Artificially accelerated radioisotopes have also been used and show some promise. Tritium labeling may also be achieved by mixing tritium-containing gas with the compound to be labeled. Energy causing the tritium to exchange with hydrogen atoms of the compound may be supplied by passing an electric discharge, by ionizing radiation from an external source, or by the self-irradiation from the beta decay of the tritium itself. High specific activities of randomly labeled compounds have been produced by these means. The chief problem associated, in various degrees, with all these new methods, is purification of the product from the labeled by-products. (auth)

14718 A/CONF.15/P/928
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
RECENT ADVANCES MADE POSSIBLE BY THE USE OF TRACER TECHNIQUES IN RADIATION CHEMISTRY. John G. Burr. 24p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A review is presented of some of the notable advances made in the understanding of radiolytic mechanisms through the use of isotopic tracers. The irradiation of mixtures of ethane and perdeuteroethane; the irradiations of perdeuterobenzene, and mixtures of this substance with other organic materials; the irradiations of perdeuteromethane and ordinary methane; the comparison between the radiolysis of ordinary water and heavy water; and, the irradiation of perdeuterodiphenyl, and its mixtures with diphenyl and partially deuterated diphenyls are included in the discussion. The irradiation of partially deuterated ethanols, partially deuterated acetic acids, and partially deuterated diphenyls is discussed. The energy of the recoil atoms as ionizing radiation, the nature of the compounds whose labeling has been reported, the products produced in the recoil process in comparison with the normal radiolysis products, and the extent and position of labeling are discussed. Also described is the use of isotope dilution in the radiolysis of aqueous acetic and formic acids, using carbon-14 tracer; and the use of isotopic halogens to elucidate the radiolysis of alkyl halides. (auth)

Transuranic Elements and Compounds

14719 A/CONF.15/P/530
Los Alamos Scientific Lab., N. Mex.
AQUEOUS DECONTAMINATION OF PLUTONIUM FROM FISSION PRODUCT ELEMENTS. R. S. Winchester and W. J. Maraman. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A survey of aqueous plutonium recovery and purification methods as applied to plutonium-rich reactor fuels has been made. These methods consist of precipitating plutonium fluoride, oxalate, and peroxide, sorbing on anion exchange resins, and solvent-extracting with tri-n-butyl phosphate. The standard fluoride, oxalate, and peroxide precipitation methods gave decontamination factors of plutonium from the typical fission product elements zirconium, molybdenum, ruthenium, and cerium ranging from 0.002 for cerium to 140 for molybdenum. Sorption of plutonium on anion exchanger resins from 8 M nitric acid solutions and the subsequent elution resulted in decontamination factors of 16 for ruthenium to 52 for zirconium. Solvent extraction of plutonium in 2.7 M nitric acid by tri-n-butyl phosphate gave decontamination factors ranging from 1.3 for ruthenium to greater than 100 for molybdenum. Extraction of plutonium from 8 M nitric acid solution by primary, secondary, tertiary, and quaternary amines gave greater over-all decontamination. The secondary amine was selected for recovery processing. Plutonium is recovered and purified from pyrometallurgical and analytical wastes on a 300-gram scale using secondary amine solvent extraction followed by oxalate precipitation. A flowsheet for this process is discussed. (auth)

14720 A/CONF.15/P/644
Naval Radiological Defense Lab., San Francisco.
EXTENSION OF THE FISSION PRODUCT REGION AND YIELDS OF HEAVY PRODUCTS IN THE NEUTRON FISSION OF Pu^{239}. L. R. Bunney, E. M. Scadden, J. O. Abriam, and N. E. Ballou. 4p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Information on observations of new fission product elements and on the more accurate definition of the Pu^{239} fission yield curve in the heavy mass region is presented. Radiochemical studies, utilizing ion exchange chromatography, of the pile neutron fission of Pu^{239} were made in the region beyong mass number 144. The fission product region was extended to include Dy^{166} and Ho^{166}. Chain yields were measured relative to Mo^{99} for masses 147, 149, 153, 156, 159, 161, and 166. The mass distribution of the fission products of Pu^{239} is wider than that of U^{233} or U^{235} since the heavy mass peak shifts toward higher mass numbers. It also exhibits a different shape on the high mass number side of the heavy peak. Fission yield values obtained in these studies expressed in % are: mass 147–2.2, mass 149–1.2, mass 153–0.35, mass 156–0.11, mass 159–0.021, mass 161–0.0040 and mass 166–0.00007. The results obtained for masses 153 and 156 are in fair agreement with previously reported values of 0.39 and 0.12%, respectively. (auth)

14721 A/CONF.15/P/701
Los Alamos Scientific Lab., N. Mex.
THERMODYNAMICS AND PHASE RELATIONSHIPS FOR PLUTONIUM OXIDES. C. E. Holley, Jr., R. N. R. Mulford, E. J. Huber, Jr., E. L. Head, F. H. Ellinger, and C. W. Bjorklund. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A compilation of available fundamental information concerning plutonium oxides. Methods of preparation, thermodynamic data, phase relationships, crystal structures, and some information on mixed oxide systems are considered. A bibliography is included. Methods of preparing PuO_2 by the peroxide and the oxalate processes and of lower oxides by the reduction of PuO_2 are described and some chemical properties of plutonium oxides of interest in processing ceramic fuel elements are given. The fabrication of PuO_2 into discs is discussed. Measurements of heats of combustion of Pu, and Pu_2O_3 are described and the heats of formation of lower oxides and PuO_2 are given. Free energy data obtained by combining estimated entropies with the measured heats of formation are tabulated for the oxides. A tentative phase diagram for the Pu–O system is presented which includes the limiting solubility of oxygen in liquid plutonium, the ranges of stability of the three known oxide phases, hexagonal Pu_2O_3, a cubic oxide inaccurately designated as "cubic Pu_2O_3," and PuO_2, and some melting point data. (The crystal structures of the plutonium oxides have already been described in the

literature and this will be reviewed.) Crystal structure data and methods of preparation for the PuO_2-UO_2, PuO_2-ThO_2, and PuO_2-CeO_2 solid solutions are described. (auth)

14722 A/CONF.15/P/760
Los Alamos Scientific Lab., N. Mex.
CONTROL OF HEALTH HAZARDS IN HANDLING PLUTONIUM. RESULTS OF 14 YEARS EXPERIENCE. H. F. Schulte and D. D. Meyer. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

As a result of 14 years of experience in handling plutonium in large batch sizes practical techniques for the control of health hazards have been developed. The health hazards involved, including both external and internal radiation, will be outlined and a brief historical review will be made of the Los Alamos experience in developing methods of handling plutonium safely. Remote handling equipment has made possible the isolation of the operators from the direct environment of the plutonium for many operations. Completely interlinked groups of ventilated dry boxes have proven most advantageous for other operations. Enclosure of parts in special containers has permitted some operations without exposure of plutonium to the atmosphere. Local exhaust ventilation and general room ventilation have been combined to limit the spread of plutonium aerosols and to direct the air flow toward the most contaminated areas and away from the operators. Good housekeeping has been a vital part of the control program. Regular monitoring of working areas, routine air sampling, and the use of protective clothing and respiratory protective equipment are described. The problems associated with air cleaning and waste disposal are discussed and practical solutions offered. An important part of the control program is routine analysis of urine samples from exposed personnel and evaluation of the data obtained. A medical program covering all Los Alamos employees contributes significantly to the control of the plutonium problem. The record of the Los Alamos Scientific Laboratory in its 14 years of experience with plutonium is reviewed briefly as a measure of the effectiveness of the control program. (auth)

14723 A/CONF.15/P/825
California. Univ., Berkeley. Radiation Lab.
METHODS OF PRODUCTION AND RESEARCH ON TRANSCURIUM ELEMENTS. Stanley G. Thompson and M. Luis Muga. 43p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Progress in the methods used for the production of transcurium isotopes since 1955 is summarized. Experimentally determined isotopic compositions resulting from long-term irradiations of isotopes in the Materials Testing Reactor are given. Tables of neutron cross sections consistent with the experimental data are listed. Calculated curves for isotopic compositions as a function of neutron flux and time are given for neutron fluxes as high as 5×10^{15}. A summary of the information available on the chemical properties of the transcurium elements is given emphasizing developments of the past three years. Recently developed techniques and methods are described for the preparation and handling of targets for charged particle bombardments. Methods used for rapid separations by chemical and recoil methods are described. Data are given concerning several types of procedures for preparing thin sources. A summary is given of the cross sections for the production of transcurium isotopes in bombardments with charged particles and very heavy ions; a method for calculating the excitation functions for heavy ion reactions is included. (auth)

14724 A/CONF.15/P/1030
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
TRANSFORMATION KINETICS OF PLUTONIUM. R. D. Nelson and I. D. Thomas. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The transformation kinetics of the alpha, beta, gamma, and delta phases of plutonium were determined using density measurements. Isothermal reaction curves of metastable beta, gamma, and delta were obtained and the time-temperature-transformation curves were sketched. The rate of transformation of alpha in the beta temperature range was determined. The temperature of the maximum rate of transformation of beta was between 0 and −20°C. The reaction was quite sluggish above 80°C. Increasing the amount of normal impurities decreases the rate of transformation and shifts the T-T-T- curves to the right. (auth)

14725 A/CONF.15/P/2247
Los Alamos Scientific Lab., N. Mex.
RECENT ADVANCES IN THE BASIC CHEMISTRY OF PLUTONIUM, AMERICIUM AND CURIUM. S. W. Rabideau, L. B. Asprey, T. K. Keenan, and T. W. Newton. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The oxidation-reduction potentials of plutonium in acid solutions were determined, enabling the estimation of equilibrium relationships among the aqueous plutonium species from electromotive force, spectrophotometric, and kinetic data. Advances in the chemistry of americium and curium included the discovery and isolation of new valence states and characterization of the metals and compounds. The results of studies of the reactions between plutonium species with each other, with oxygen, V(III), and U(IV) are presented, along with a discussion of solid phase studies of americium and curium. (J.R.D.)

Uranium and Uranium Compounds

14726 A/CONF.15/P/439
Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn.
ECONOMICS OF UNIRRADIATED PROCESSING PHASES OF URANIUM FUEL CYCLES. J. P. Murray, F. S. Patton, R. F. Hibbs, and W. L. Griffith. 25p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Expanding reactor programs present industrial opportunities in their fuel processing phases. This paper considers the manufacture of unirradiated uranium fuel materials, including the conversion of uranium hexafluoride to uranium metal, uranium dioxide, etc.; their subsequent fabrication into fuel elements; and the processing and recycle of accrued scrap. The intent is to offer potential processors an insight into operational and economic parameters associated with such enterprises. Process flow cycles and detailed economic analyses have been prepared for the following reactor fuels: (1) Uranium alloy (1.87% uranium-235) containing 2% zirconium, considered as fuel for the Consumers Public Power Reactor. (A cost analysis for 1.87%

uranium-235 nonalloyed uranium is also presented.) The initial reactor charge is 30,000 kg uranium, and annual steady-state requirements are 21,000 kg uranium as slugs, 0.455 in. O.D. × 12 in. The initial charge would remain in the reactor 435 days. (2) Slugs of dense fired uranium dioxide (1.8% to 2.1% uranium-235) for a hypothetical reactor. The initial reactor charge is 200,000 lb of uranium dioxide and the annual steady state requirements are 50,000 lb of uranium dioxide as slugs. The initial charge plus 25% of the annual make-up would be made in one year. The relative economics of a small processing plant supporting only the Consumers Public Power Reactor and a larger plant (six fold capacity) of versatile design such that many types of fuels could be processed were appraised. Unit processing costs for the larger versatile plant (or "Job Shop") were found to be approximately one-half as great. The advantage of the "Job Shop" in a period of limited demands and diversified fuels, arises from its approach to large scale, continuous processing and the attendant more favorable distribution of fixed costs and those variable costs not directly proportional to throughput. For every kilogram of uranium–zirconium alloy produced as finished slugs, approximately 0.5 kg of remeltable scrap is recycled and additional scrap containing approximately 0.4 kg uranium is processed through chemical recovery facilities. Correspondingly, for every kilogram of uranium dioxide produced as slugs, approximately 1.2 kg of uranium is recycled. The unit cost in "Job Shop" of nonalloyed uranium slugs was found to be about three-fourths of the cost of the uranium–zirconium alloy slugs, and the cost of uranium dioxide slugs was about two-thirds the cost of the uranium–zirconium slugs. All unit costs were about one-tenth greater at a 70% production level than at 100% utilization of facilities, and about twice as costly at 25% utilization. Uranium processing cost variables over the assay range of 0.7115% to 95% uranium-235 were reviewed. Included were the following topics: (1) The relationship of "lists of uranium cost versus uranium-235 assay" to the extent of salvage processing. (2) The costs of health physics protective measures for different uranium-235 assays. (3) The costs of nuclear safety protective measures for different uranium-235 assays. (4) Cost relationships for fuel fabrication facilities, scrap processing facilities, and irradiated fuel element processing facilities being at the same or different sites. (5) Reduction of traffic with gaseous diffusion plants by blending uranium recovered from irradiated fuel processing facilities with other available enriched uranium to achieve a desired uranium-235 content. (auth)

14727 A/CONF.15/P/442
Oak Ridge Gaseous Diffusion Plant, Tenn.
THE U-236 PROBLEM IN THE COMBINED OPERATION OF NUCLEAR POWER REACTIONS AND ISOTOPE SEPARATION PLANTS. G. A. Garrett and S. A. Levin. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The effect of U^{238} on the U^{235} separation process is considered in detail. The calculations are based on a model of the gaseous diffusion isotope separation cascade in which no mixing of streams which differ in U^{235} concentration takes place. The effect of U^{236} on the cost of enriched U is calculated and the results are given. A more complex case with alternate modes of operation is also considered. (M.H.R.)

14728 A/CONF.15/P/498
Dow Chemical Co. Great Western Div., Pittsburg, Calif.
IMPROVED METHODS FOR THE PREPARATION OF HIGH-PURITY URANIUM SALTS. R. S. Long, D. A. Ellis, and J. E. Magner. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Studies of possible alternate processes for making high-grade UF_4 from uranium ore leach solutions at the ore processing mills are reported. Each mill has a stream which contains uranium in fairly high concentration. Typical of these streams are the HCl strip solutions (8 to 9M HCl) obtained in the DDPA solvent extraction process and the eluates from column IX and RIP plants. These are obvious starting points for purification processes. The methods used have been to find organic extractants specific for uranium, to determine the best conditions for extraction from the aqueous solution and the conditions for recovery of pure UF_4 products from the organic extractants. (auth)

14729 A/CONF.15/P/503
National Lead Co., Inc. Raw Materials Development Lab., Winchester, Mass.
PREPARATION OF DENSE, METAL GRADE URANIUM TETRAFLUORIDE FROM URANIFEROUS ORES. R. J. Allen, H. G. Petrow, and A. Whitman. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An extensive program directed towards the production of dense, metal grade UF_4 from uraniferous ores was conducted. The research effort was divided into three parts: the preparation of a pure concentrated uranium solution from sulfuric acid leach liquors; the development of a means of reducing uranium and precipitating UF_4; and the development of a drying technique capable of dehydrating UF_4 without materially affecting its physical or chemical properties. (auth)

14730 A/CONF.15/P/508
Division of Raw Materials, AEC.
PROSPECTS FOR RESEARCH AND DEVELOPMENT EFFORT TO DECREASE COSTS OF RECOVERING URANIUM FROM ITS ORES. T. B. Upchurch. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The various unit operations involved in the recovery of uranium from ores are summarized, together with a brief history of the development of the technology as practiced today throughout most of the world. An economic analysis is made of each step of each process to show what portion it represents of the total cost of producing the uranium end product. In addition, each unit operation is analyzed with respect to the degree of freedom remaining for improvement. The objective of these analyses is to present an economic basis for use in the planning and management of any research or development program in the field of uranium production The assessment of the possibilities of techniques different from those that have become standard in uranium practice will also be expressed in terms of potential gain, again with the objective of offering guidance to expenditure of research or development effort. In conclusion as a result of the analyses discussed in detail a summary will be made of the areas that show the greatest promise of giving the most return for the investment of future research and development effort. (auth)

14731 A/CONF.15/P/523
Oak Ridge Gaseous Diffusion Plant, Tenn.
CONTINUOUS PROCESSES FOR THE DIRECT REDUCTION OF URANIUM HEXAFLUORIDE TO URANIUM TETRAFLUORIDE OF HIGH PURITY AND

DENSITY. S. H. Smiley and D. C. Brater. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Contrary to the published literature, the single-step reduction of uranium hexafluoride to uranium tetrafluoride with hydrogen was found to be quantitative; furthermore, a highly efficient, continuous process, both safe and economical, was developed and adapted for large-scale production use. The uranium tetrafluoride product was of high density and purity. The basic hydrogen reduction method is actually uncomplicated; uranium hexafluoride and about 100% excess hydrogen, both preheated to approximately 500°F, are charged into the top of a vertical pipe reactor which is heated to about 1000°F, and complete reduction to uranium tetrafluoride is realized almost instantaneously. The uranium tetrafluoride, having a packed density of 220 lb/ft^3 (3.5 g/cc) and an impurity content of 30 to 50 ppm, is collected in a hopper at the bottom of the pipe. The gaseous products are passed through a metallic filter to remove entrained solids, and pure anhydrous hydrogen fluoride is recovered as a reaction by-product. The only operating difficulty noted is that slow accumulation of fused uranium fluorides, UF_5, U_2F_9, and U_4F_{17}, on the hot reactor walls necessitates periodic deslagging of the unit; however, where large quantities of low assay materials are required and relatively large equipment can be used, the loss in operating time is small. The significance of the development of the hydrogen reduction method is best realized by comparing it to existing wet processing schemes. Feasibility studies showed that the latter methods were both economically and operationally unattractive for handling large quantities of uranium hexafluoride. Bulky equipment built to withstand corrosion from aqueous hydrogen fluoride solutions, as well as expensive precipitators, filters, dryers, and converters for the required multiplicity of operation, made costs prohibitive. Some modification of the "hot wall" method was necessary to process higher assay uranium hexafluoride. Since the equipment must be small to meet criticality dimensional requirements, and opportunities for loss of uranium must be minimized, slagging of the reactor became a serious problem. It was found that the solid deposits could be eliminated entirely if fluorine was added to the uranium hexafluoride stream and the reactor walls were maintained at a low temperature; i.e., about 300°F. The highly exothermic reaction of the fluorine with hydrogen supplied the energy required to initiate and sustain the reduction, and the major portion of the reaction appeared to take place in a narrow flame directly below the gas nozzles. The solid product did not stick to the cool reactor walls, and a reliable correlation between the uranium tetrafluoride density and the amount of fluorine added was established. A process to reduce uranium hexafluoride with gaseous trichloroethylene was also developed. Complete conversion to uranium tetrafluoride was realized, but under most conditions the product was low in density and highly contaminated with the organic by-products; thus, additional treatment was required to make an acceptable material. Pure uranium tetrafluoride could be obtained directly by this method, however, if the stream containing uranium hexafluoride was very dilute, i.e., about 1% uranium hexafluoride in nitrogen. Complete reduction of uranium hexafluoride was also possible with liquid trichloroethylene in a spray column, but it was difficult to separate the solid product from the liquid. (auth)

14732 A/CONF.15/P/525

Oak Ridge Gaseous Diffusion Plant, Tenn.

THE DEVELOPMENT OF A HIGH CAPACITY, CONTINUOUS PROCESS FOR THE PREPARATION OF URANIUM HEXAFLUORIDE FROM URANIUM OXIDES AND ORE CONCENTRATES. S. H. Smiley and D. C. Brater. 23p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Methods and equipment were successfully developed for converting uranium oxides to uranium hexafluoride continuously and economically. The process involves a series of three highly exothermic reactions in which uranium trioxide is converted to dioxide with hydrogen, to tetrafluoride with anhydrous hydrogen fluoride, and finally to hexafluoride with fluorine. The hexafluoride can be recovered by solid condensation, liquefication, stripping by an organic solvent, or absorption-desorption, employing solids such as uranium tetrafluoride or sodium fluoride as carriers. Several types of reactors for each of the process steps are evaluated, and new and unique methods for increasing oxide reactivity are presented. Considerable test data are included. Uranium hexafluoride collection methods and a newly developed fluid-bed stripper, which is used for final clean-up of uranium hexafluoride from vent gases, are described. Uranium hexafluoride distillation techniques are also discussed. The results of the pilot-plant investigation of a process for converting impure ore concentrates directly to uranium hexafluoride are examined. (auth)

14733 A/CONF.15/P/534

General Electric Co. Hanford Atomic Products Operation, Richland, Wash. and Utah. Univ., Salt Lake City.

THE FLUREX PROCESS: A WET CHEMICAL METHOD FOR THE PRODUCTION OF URANIC FLUORIDE SALTS. W. W. Schulz, E. W. Neuvar, J. L. Carroll, and R. E. Burns. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The basic element of the Flurex Process is a three compartment electrolytic cell having a center feed compartment separated from the anode compartment by an anion permeable membrane and from the cathode compartment by a cation permeable membrane. Ideally, uranyl nitrate enters the feed compartment from which nitrate ion passes through the anion membranes to the anolyte and uranyl ion through the cation membrane to the catholyte. In practice, the ion permeable membranes do not exhibit complete perm-selectivity. Cations present in the anolyte migrate into the feed chamber and on the catholyte, also cations present in the feed are transferred to the catholyte, in addition, water is carried by both uranyl ion and nitrate ion as they pass through the ion permeable membranes. A discussion of the magnitude and effect of these departures from ideal conditions as a function of operating variables, is presented. (J.R.D.)

14734 A/CONF.15/P/542

Argonne National Lab., Lemont, Ill.

FLUIDIZATION TECHNIQUES AS APPLIED TO REACTOR FUEL PROCESSING. S. Lawroski, A. A. Jonke, N. Levitz, and E. J. Petkus. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Developments in fluidized-bed technology as applied to the processing of nuclear fuel materials, both irradiated and non-irradiated are discussed. Continuous conversion of recovered and decontaminated uranyl

nitrate solution to uranium trioxide in a fluidized-bed calciner was demonstrated in pilot scale equipment. Concentrated uranyl nitrate solution is continuously atomized and fed to the hot agitated uranium trioxide bed, resulting in thermal decomposition of the uranyl nitrate. Recent studies show that from this uranium trioxide it is possible to produce uranium dioxide of high chemical reactivity by hydrogen reduction in a fluidized-bed reactor. The improved reactivity results from the ability to control and maintain uniform reaction temperatures in the fluidized-bed reactor. Multistage, fluidized-bed equipment for pilot-scale production of uranium dioxide and uranium tetrafluoride has been designed and successfully operated. Use of such equipment permits countercurrent contact between reactant gases and solids, and allows temperature gradients to be used. The development of separation processes consisting of dissolution in aqueous media, evaporation in a fluidized-bed calciner, and fluorination in a fluidized-bed reactor are described. Separated uranium hexafluoride can then be decontaminated by proved methods employing fractional distillation. Work on application of this process to plutonium-bearing fuels has also been initiated. (auth)

14735 A/CONF.15/P/602
Mallinckrodt Chemical Works, St. Louis.
THE NEWEST UNITED STATES URANIUM PROCESSING PLANT. Harold E. Thayer. 24p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The refining operation is carried out in pumper-decanter extraction units, designed to operate with a TBP-hexane solvent system, which permits the attainment of very high through-put per square foot of cross section. Washing of the extract and re-extraction into water is accomplished in pulse columns with teflon-coated perforated plates, which also have high throughput. Both saturation control and a second extraction cycle using diethyl ether are available, providing optional means of attaining the ultimate in purity of product. The production of green salt is carried out in the tubular stirred bed reactors which have proven so successful in the past. Improved production rates are achieved, however, through the use of fluid bed equipment for the reduction step. The UO_2 intermediate is suitable for diversion to power reactor fuel element usage. The UF_4 product is suitable for conversion to UF_6 or to metal. (auth)

14736 A/CONF.15/P/710
Battelle Memorial Inst., Columbus, Ohio.
REACTIVITY OF URANIUM COMPOUNDS IN SEVERAL GASEOUS MEDIA. W. M. Albrecht and B. G. Koehl. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Corrosion studies were made of several uranium compounds with oxygen and nitrogen and in some cases with water vapor. The compounds, USi, USi_2, USi_3, U_3Si_2, UAl_2, UC_2, UBe_{13}, and UB_2 were investigated. Vacuum sintered compacts of the various materials which had bulk densities greater than 75% of theoretical were used. The nominal compounds had about 5 to 10% of one or more other phases present. The rates of reaction of the compounds with the gases were determined for periods up to three hours. Weight-gain measurements were obtained using a Sartorius Electrona microbalance. The rates of reaction of oxygen with UBe_{13}, UB_2, and USi increases in that order and initially follow a linear rate law up to 400°C. Above about 400°C both the UB_2 and USi reacted anisothermally, that is, the temperature of the specimens increased and caused the rate of reaction to increase rapidly with time. In contrast, the UBe_{13} reaction was isothermal at temperatures up to 600°C. The reactions of oxygen with the compounds, listed in order of increasing rates, USi_3, USi_2, U_3Si_2, and UC_2 follow a parabolic rate law up to about 400°C, while the oxidation of UAl_2 follows a cubic law. In contrast, pure uranium oxidizes linearly at these temperatures. In nearly all cases, U_3O_8 was the only oxidation product detected by x-ray analysis. The reaction of nitrogen with all the compounds follows a parabolic law at temperatures up to 600 to 800°C. UB_2 was the only material that reacted more slowly with nitrogen than did uranium under similar conditions. However, in all cases the reactions of the compounds with nitrogen were slower than the reactions with oxygen at the same temperatures. The nitrogen reaction product in each case was principally UN_x where x is greater than 1.5. The reactions of water vapor at 29 mm of mercury with UBe_{13}, UB_2, and UC_2 follow a linear rate law. These reactions are slower than the reaction of oxygen with the compounds. UO_2 was the only product of reaction with water vapor detected by x-ray analysis. (auth)

14737 A/CONF.15/P/779
Geological Survey, Denver.
THE ROLE OF HUMIC ACIDS IN THE GEOCHEMISTRY OF URANIUM. J. D. Vine, V. E. Swanson, and K. G. Bell. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Carbonaceous matter is probably the most characteristic component of sedimentary rocks containing abnormal concentrations of uranium, but much evidence suggests that only certain types of carbonaceous matter have the capacity to assimilate, fix, or transport uranium. The indigenous carbonaceous matter in sedimentary rocks is considered here as a complex, gradational series of organic remains with three distinct end-members—decayed wood, hydrocarbons, and carbon. Two major categories of carbonaceous matter may be recognized: sapropelic and humic. Sapropelic matter is rich in hydrogen and yields bitumens. Humic matter is rich in oxygen and yields humic acid extracts to alkaline solutions. Carbon is the metamorphic end product of both humic and sapropelic matter. Solid humic matter and the extracted humic acids are the important carbonaceous materials in the geochemical cycle of uranium. Experimental results show that humic substances are capable of assimilating 5 percent or more of uranium by dry weight from uranyl solutions forming uranyl humate. Solid humic matter is the principal constituent of peat, lignite, and of the dispersed carbonaceous matter in non-marine sedimentary rocks. Natural alkaline solutions such as sodium carbonate ground water readily extract humic acids from the solid humic matter to form a colloidal solution; upon acidification, or addition of some salts (e.g., those of calcium), the dispersed humic acids flocculate to form a reddish-brown gel. Humic acids and humates readily remove uranium from solution by adsorption, ion exchange, or chemical complexing. Once assimilated, the uranium remains fixed under most natural conditions of transportation and deposition. Some carbonaceous uranium ore deposits of the type commonly but erroneously called "uraniferous asphaltite" are thought to represent deposits of uranyl humates that have been carbonized and indurated by alpha-particle irradiation. Evidence is presented to show that a small humic-matter component

of the carbonaceous material in marine black shales may be responsible for retaining most of the uranium disseminated in these rocks. (auth)

14738 A/CONF.15/P/1015
National Lead Co. of Ohio, Cincinnati.
A MOVING BED REACTOR FOR THE PRODUCTION OF URANIUM TETRAFLUORIDE. D. S. Arnold, P. W. Henline, and R. H. Sisson. 25p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Design and operating criteria for a moving bed reactor system for the production of uranium tetrafluoride from uranium trioxide have been developed from laboratory and pilot plant investigations. Basic parameters for the sequence of steps involving extrusion pelleting of an oxide-water mixture, drying, dehydration, reduction, and hydrofluorination have been determined and are reported. Performance data for the moving bed type countercurrent gas-solids reactors of one square foot cross section are reported. Typical thermal and concentration gradient data from the pilot plant reactors and related chemical kinetic and equilibria data from laboratory thermogravimetric balance tests are included. Techniques developed for overcoming pellet fabrication and reactor operation difficulties are described. Problems encountered included non-uniform mixing of the uranium oxide and water, plugging of the extruder, and temperature and flow control in the moving bed reactors. Minimum feed rates for stable reactor operation were established. Minimum and maximum reactor bed temperatures were investigated. Heat transfer coefficients under varying reactor operating conditions were measured. A conceptual design and cost estimate for a 5000 ton per year plant has been prepared to demonstrate the application of criteria and principles described. (auth)

14739 A/CONF.15/P/1548
Argonne National Lab., Lemont, Ill.
THE URANIUM–OXYGEN SYSTEM: U_3O_8 TO UO_3. Henry R. Hoekstra and Stanley Siegel. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Results of investigations on the uranium–oxygen system and on several related binary oxide systems are presented. A survey of recent publications is included in order to present a complete picture of current work in this field. Studies of the structure of U_4O_9 indicate that the oxide may not crystallize in the simple fluorite lattice which has been generally accepted for this compound. The U_3O_8 phase has a relatively narrow composition range below which it converts to a larger orthorhombic cell whose composition range extends from $UO_{2.56}$ to $UO_{2.65}$. The preparation and some properties of four crystalline modifications of UO_3 are described as well as methods for interconversion of structural types. Studies of UO_3 hydrates under various conditions of temperature and pressure are included. Alkali metal uranate systems were investigated at elevated temperatures, and their methods of preparation are described. The preparation of zinc and lead uranates and their thermal stability are discussed. (J.E.D.)

14740 A/CONF.15/P/1840
Paducah Gaseous Diffusion Plant, Ky.
CURRENT MANUFACTURING PROCESSES USED IN THE UNITED STATES FOR MASS PRODUCTION OF UF_6 FROM PURIFIED UO_3. C. A. Powell. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A plant for the economical, safe, and efficient production of UF_6 is described. The UO_3 from solvent extraction of virgin ore concentrates or from reprocessed spent reactor fuels is converted continuously and automatically to UF_4 in reactors using fluid bed reduction and ribbon screw hydrofluorination. Uranium hexafluoride is produced by treating UF_4 with preheated F_2 in a water cooled flame reactor; the UF_6 is frozen in a heat exchanger and liquefied. The process employs a graphic panel control center from which all process variables and equipment are controlled. The chemical efficiencies are high; the HF efficiency is 99%, the F_2 efficiency is 99%, and the uranium yield is 99.99%, or essentially no loss. The plant is relatively small, requiring a moderate capital outlay, and it produces UF_6 at very low cost. (auth)

14741 A/CONF.15/P/1889
National Lead Co. of Ohio, Cincinnati.
PRODUCTION OF LOW ENRICHMENT URANIUM FUEL ELEMENT CORES. F. L. Cuthbert, C. E. Crompton, J. O. Davis, and C. E. Polson. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Reduction of enriched gaseous uranium hexafluoride to uranium tetrafluoride with dissociated ammonia, reduction of uranium tetrafluoride to metal with magnesium metal, vacuum casting of uranium ingots, and subsequent fabrication steps such as swaging and machining are discussed. Also presented are other aspects of production such as: the reclamation and direct recycle of enriched metallic residues by the technique of atmospheric melting under a salt cover, the handling of enriched wastes requiring chemical recovery, and the nuclear safety criteria adopted in a this production and fabrication operation to insure that these amounts of enriched uranium do not approach a nuclear or critical incident. Such criticality controls will also be discussed as an important aspect of the shipment of finished fuel elements by various means of transportation. (auth)

14742 A/CONF.15/P/1987
Los Alamos Scientific Lab., N. Mex.
HEALTH PHYSICS ASPECTS OF HANDLING URANIUM-233 FEED MATERIAL. J. N. P. Lawrence. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The processes of separation, purification, and fabrication of feed materials containing U^{232}, U^{233}, U^{234}, U^{235}, and U^{238} require much closer health physics supervision than do the enriched or naturally occurring mixtures of U^{234}, U^{235}, and U^{238} found in natural uranium. The primary problem is the control of alpha and gamma radiation. The isotope U^{233} presents only an alpha control problem; however, the daughters of U^{232} constitute a gamma problem. Because of the high specific activity of these materials, all chemical purification, metallic casting, and fabrication is done in dry boxes. A discussion of the maximum permissible body burden and the maximum permissible air concentration is presented, including protective measures against exposure. Los Alamos experience with gamma radiation in chemical purification and metal fabrication is summarized. (J.R.D.)

14743 A/CONF.15/P/2404
Westinghouse Electric Corp. Bettis Plant, Pittsburgh.
PROPERTIES OF URANIUM DIOXIDE. J. Belle. 55p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The use of UO_2 as a reactor fuel led to extensive investigations of its chemical, metallurgical, and physical properties. Some of the information gained in these investigations is presented. Included are data on powder preparation, powder characteristics, sintering characteristics, physical properties, and diffusion kinetics. A 63-reference bibliography is included. (D.E.B.)

Waste Disposal

14744 A/CONF.15/P/389

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

THE STORAGE OF HIGH LEVEL RADIOACTIVE WASTES. DESIGN AND OPERATING EXPERIENCE IN THE UNITED STATES. O. H. Pilkey, A. M. Platt, and C. A. Rohrmann. 31p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In the atomic energy industry in the United States the processing of nuclear reactor fuel at many sites yields hazardous fission product waste mixtures in the form of concentrated aqueous solutions which must be securely and permanently stored with maximum assurance against uncontrolled release to the environment. The present method, with which there has been about fourteen years of successful industrial experience, comprises storage underground in steel tanks encased in reinforced concrete. Until methods are developed with demonstrated and improved reliability and at substantially lower costs, it is expected that this storage technique will continue to be used for these large scale operations. Most of the wastes are maintained as alkaline solutions to permit the use of ordinary steel; however large-scale storage is also done in stainless steel with acid wastes. The chemical processing of nuclear fuel has been improved to the extent that the radioactive decay of the concentrated fission products generates heat sufficient to maintain the waste fluids at the boiling temperature for many years. Aside from the needs for extremely reliable design and construction, facilities must be provided for the removal of this heat. In some installations this heat is used to concentrate the wastes and thus achieve smaller volumes for storage. In such cases additional facilities are required to remove the radioactive particulate matter which may be entrained in the evolved steam. In other cases this particulate problem is avoided by cooling the liquid wastes to maintain temperatures below boiling or by returning the condensate to the tanks. Under such conditions the release of particulate matter in the vent gases is greatly minimized. In the large-scale storage of self-heating wastes there is the phenomenon of cyclic boiling. This is critical from the standpoints of release of radioactivity from vents and from the structural security of the tanks which are subjected to such pressure surges. The use of air circulators has completely eliminated this unusual industrial problem. These air circulators are simple in design and operation but must have the utmost reliability throughout the "boiling life" of the storage facilities. The severe conditions involving mass of material, temperature, intense radioactivity, boiling and the prolonged storage period require careful control of the materials delivered to the storage facilities. Possibilities of thermal decomposition and radiolysis which may yield corrosive or explosive gases must be recognized and avoided by analysis and control of process streams which may be diverted to waste storage. Proposals for the adoption of other storage methods must be critically evaluated to determine the extent to which the problems related to the these severe conditions are minimized. The progress that has been made in waste volume reduction is such that by selection of fuel composition and choice of separation process the cost of waste storage need not be a major element in the cost of the total fuel cycle for nuclear power production. (auth)

14745 A/CONF.15/P/395

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

THE REMOVAL OF STRONTIUM FROM WASTES BY A CALCITE–PHOSPHATE MECHANISM. L. L. Ames, Jr., J. R. McHenry, and J. F. Honstead. 14p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A promising mechanism for selectively removing strontium from aqueous fission product wastes involves the formation of strontian apatite on growth sites furnished by crystalline carbonates of the alkaline earth metals, such as calcite. It was found that when such aqueous solutions are made alkaline and 0.05 M with phosphate ion and are passed over crystalline calcium carbonate, the strontium is removed to a very large extent, apparently depending upon the solubility of the apatite in the system. The reaction proceeds equally well in low-salt solutions and 4.0 M solutions of $NaNO_3$. The selectivity of the reaction for strontium isotopes, and the nearly complete strontium removal provided, suggest several possible applications. Calcite is a very common mineral in many semi-arid regions, such as are found in various locations in western United States. Low level fission product waste solutions may be treated with phosphate ion, neutralized and discharged directly to such soils with assurance that the strontium isotopes will be effectively retained on the calcite in the soil. The reaction may also be used to remove strontium in a nearly insoluble form from high level waste solutions. (auth)

14746 A/CONF.15/P/397

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

TREATMENT OF RADIOACTIVE WASTE GASES. A. G. Blasewitz and W. C. Schmidt. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The disposal of radioactive waste gases from the plant-scale processes at the Hanford Atomic Products Operation presents a problem that is of considerable importance in plant operation. Equipment developed for the efficient removal of the two principal contaminants: 1) gaseous radioactive iodine; and 2) an aerosol composed of other fission products is described. The program has led to the development of the silver reactor for the removal of gaseous iodine and deep-bed, glass-fiber filters for removing the particulate matter suspended in the gas streams. Field data and the empirical equations established for design purposes are presented. The manner in which the design data were used to select equipment to meet particular plant problems is likewise discussed. The operating performance of the plant-scale silver reactors and glass-fiber filters has been highly satisfactory. The difficulties experienced in operating the equipment are described. (auth)

14747 A/CONF.15/P/1073
Oak Ridge National Lab., Tenn.
MULTIPURPOSE PROCESSING AND ULTIMATE DISPOSAL OF RADIOACTIVE WASTES. E. G. Struxness and J. O. Blomeke. 23p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The many unit processes and unit operations applicable to integrated waste processing and ultimate disposal systems are discussed. The flow diagrams are useful in presenting the concept of multipurpose waste processing as a necessary companion to multipurpose fuel reprocessing. The steps for processing wastes of different types include: evaporation, acid and neutralized storage, solid-liquid separation, extraction of useful or hazardous fission products from various liquid fractions by solvent extraction, precipitation, continuous ion exchange and electrodialysis, and fusion or sintering of solid fractions. The methods of disposal, considered here as an integral part of the waste complex, are: land burial of low level solids; land disposal of low level liquids in zones above the water table; sea disposal of low level liquids and solids; disposal of intermediate level and/or low level liquids in porous media below the water table; and disposal of intermediate level and/or high level solids and/or liquids in salt cavities or dry mines. Consideration is given to the packaging and transportation of wastes to disposal sites, to the treatment of contaminated gaseous effluents from various segments of the complex, and to the recycling of low activity water, sodium hydroxide, and nitric acid in waste processing. (auth)

14748 A/CONF.15.P/1768
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
FISSION PRODUCT RECOVERY FROM RADIOACTIVE EFFLUENTS. R. L. Moore and R. E. Burns. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Processes are described for the recovery of cesium-137 from Purex type, first cycle waste solutions which result from the solvent extraction reprocessing of reactor fuels. Flowsheets are presented for recovering cesium from neutralized wastes by coprecipitation with zinc ferrocyanide or from acidic solution by precipitation with zinc ferricyanide or zinc cobalticyanide. Further processing converts the cesium to cesium chloride, a stable form suitable for use in high intensity gamma irradiation sources. Modification of the cesium recovery process enables isolation of other valuable products including rare earths, cerium-144, and strontium-90 activities. Experience at Hanford Atomic Products Operation in the use of similar procedures for decontaminating certain effluents prior to discharge to the ground is described. A comparison of objectives and results obtained in these procedures to those suggested for fission product recovery is made. The effect of recovering certain fission products, particularly long-lived nuclides, from effluents on temporary or long term storage or disposal of the effluent is discussed. (auth)

14749 A/CONF.15/P/2004
[Division of Reactor Development], AEC.
THE ROLE OF WASTE MANAGEMENT IN THE DEVELOPMENT OF THE NUCLEAR ENERGY INDUSTRY. Joseph A. Lieberman. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Distinction is made between the various categories of radioactive wastes evolving from different segments of the nuclear energy industry. Capabilities and operating experience of treatment and disposal systems presently in use for low-level wastes from laboratories and reactors are described. Emphasis is given to the highly radioactive liquid wastes resulting from the chemical reprocessing of irradiated nuclear fuels. Present handling and treatment methods for this category of wastes are discussed. Development activities directed toward ultimate disposal systems for high-level wastes are noted. Distinction is made between treatment and disposal systems which have been engineered to prototype scale and those systems which are in the development stage. Based on present knowledge, judgments on the evolution of ultimate disposal systems are given. Basic criteria pertinent to ultimate disposal of highly radioactive wastes including the environmental aspects are delineated. (auth)

14750 A/CONF.15/P/2351
Oak Ridge National Lab., Tenn.
DISPOSAL OF HIGH LEVEL RADIOACTIVE LIQUID WASTES IN TERRESTRIAL PITS—A SEQUEL. W. de Laguna, K. E. Cowser, and F. L. Parker. 32p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Operating procedures for the three 200 × 100 × 15 feet pits are given. Methods for detecting the motion of wastes in the Conasauga shale are described. The conclusion is that it is virtually impossible to predict from any known method of pretesting, in a proposed site in the Oak Ridge area, how a waste disposal pit will operate. (W.D.M.)

14751 A/CONF.15/P/2354
Oak Ridge National Lab., Tenn.
THE TREATMENT OF LARGE-VOLUME, LOW-LEVEL WASTE BY THE LIME-SODA SOFTENING PROCESS. K. E. Cowser, Roy J. Morton, and E. J. Witkowski. 28p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

At Oak Ridge National Laboratory, the collection and disposal of large volume (0.5 to 0.7 million gpd), low level radioactive liquid waste is accomplished through a process waste water system. The wastes from laboratory sinks, decontamination-pad drains, floor drains, storage canals, evaporator condensates, and water from various development processes are collected in an excavated settling basin (approximately 1.6 million gallons design capacity) and discharged through a continuous flow-measurement, proportional-sampling station into White Oak Creek, White Oak Lake (a 50 acre, 10^7 ft^3 impoundment), and the Clinch River. To Minimize the danger of accidental or emergency discharges and increase the factor of safety for normal operations, a process waste water treatment plant was essential. The plant employs gravimetric chemical feeding, flash mixing, coagulation, and sedimentation, and has a capacity of 500,000 gallons per day. The recirculation of plant effluent, the return of preformed crystals (sludge), and repeated precipitation is possible. An 800,000 gallon equalizing basin is provided to minimize fluctuations in chemical composition of the influent wastes. Operating experience during the past year has shown that the plant is capable of removing 90% of the radioactive strontium and rare earths and reducing the calcium content to less than 30 ppm. Operation of the plant is controlled by routine analytical determinations and is being improved by statistically designed laboratory studies. (auth)

14752 A/CONF.15/P/2359
Robert A. Taft Sanitary Engineering Center, Cincinnati.
WASTE CHARACTERISTICS FOR THE RESIN-IN-PULP URANIUM EXTRACTION PROCESS. E. C. Tsivoglou, D. C. Kalda, and J. R. Dearwater. 21p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Field and laboratory investigations designed to develop information leading to the safe, economical disposal of wastes from the uranium ore refining industry are discussed. Studies were made tracing the course of radioactive materials, particularly radium, through the refining process in a resin-in-pulp uranium recovery plant in the western United States. The mill had been in operation about one year, during which time all liquid wastes were confined in a tailings pond except for a brief discharge of clarified liquor to a nearby stream. The various plant process streams were sampled for a week on consecutive days, with compositing and investigation of periodic quality changes. Sampling was based on a preliminary survey of the plant and development of an accurate flow diagram. Analytical results include gross radioactivity, radium, and other process stream quality determinations. Details of the planning and performance of the survey are also presented. Results include a radium balance through the resin-in-pulp process, and indicate the effects of the various process steps on the solubility of the radium involved. Characteristics of the waste streams are discussed and their disposal considered in terms of effects on present and potential uses of the receiving river. (auth)

14753 A/CONF.15/P/2441
North Carolina. Univ., Chapel Hill.
SOME FUNDAMENTAL PROBLEMS IN FIXATION OF RADIOISOTOPES IN SOLIDS. Henry C. Thomas. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The stability of radioactive glasses and sinters and the problems of mobility of radioactivity within masses of earth are discussed. Diffusion in crystals and glasses, the stability of sinters, and adsorption and the motion of radioactive nuclides in wet earth are the topics covered. (T.R.H.)

ENGINEERING

14754 A/CONF.15/P/2008
Yale Univ., New Haven. Sloane Physics Lab.
A BASIC TRAINING COURSE FOR NUCLEAR ENGINEERS. William J. Knox. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A course of instruction was developed in which engineers are introduced to the basic concepts of nuclear physics and reactor physics through a series of correlated lectures and laboratory experiments. The subject matter of the course includes radioactivity, interaction of charged particles and radiation with matter, nuclear reactions, neutron interactions, and an introduction to reactor physics. Experiments are divided into groups in each of which a student may perform a basic experiment or carry out more extended work depending on the amount of laboratory time available. (auth)

Heat Transfer and Fluid Flow

14755 A/CONF.15/P/720
Oak Ridge Gaseous Diffusion Plant, Tenn.
EFFECTS OF POROUS BOUNDARIES ON THE FLOW OF FLUIDS IN SYSTEMS WITH VARIOUS GEOMETRIES. Abraham S. Berman. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Descriptions of flow fields have been obtained for the case of an incompressible fluid in steady state, laminar, two-dimensional flow in pipes, channels, and annuli with fluid injection or suction at the walls. Solutions of the Navier-Stokes equations for these systems provided a description of the variations of the velocity and pressure drop components with the amount and direction of the fluid flow through the system boundary as well as the effect of system geometry on these variations. The solutions obtained and encompass the complete range of fluid injection and suction velocities. Fluid injection or withdrawal through the system boundaries has a marked effect on velocity profiles and pressure drops. The changes from the familiar parabolic velocity profiles are much more pronounced when fluid is removed from the system boundary than when fluid is injected. These changes are discussed in detail as are the pronounced changes in the pressure drops. It is shown that relatively small amounts of suction can produce pressure rises in the direction of the main flow. Comparisons are made between the solutions obtained and those which recently appeared in the literature. (auth)

14756 A/CONF.15/P/1761
California Research Corp., Richmond, Calif.
FLOW MEASUREMENTS BY THE TOTAL-COUNT METHOD. D. E. Hull and M. Macomber. 21p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A fundamentally new method of measuring fluid flow uses a pulsed charge of radioisotope and a radiation counter. It is based on this principle: When a discrete quantity of radioactive tracer (A) flows past a counter fixed in or near the stream, the total number of counts (N) from the tracer is inversely proportional to the flow rate (Q). The counter must be calibrated in a geometry simulating that on the stream and with the isotope at a known concentration. The calibration factor (F) is expressed in counts/second per mc/ft^3. Thereafter, to determine the flow in any such stream, all one needs to know is the quantity of isotope put in the stream and the total counts recorded while it passes. The flow is given by the formula: $Q = AF/N$. The total-count method has many fields of application. Because it is a general solution to the problem of measuring flow, it can be used to calibrate all other types of flow gages. It easily gives an accuracy of 5%; with care it can be used to 2%. No installations or alterations to piping are necessary and no empirical formulas are used. It does not impede the flow to be measured, and it can be used where no pressure drop or hydrostatic head is available. (auth)

14757 A/CONF.15/P/1983
Argonne National Lab., Lemont, Ill. and Combustion Engineering, Inc. [Reactor Development Div.], Windsor, Conn.
EXPERIMENTAL STUDIES OF NATURAL CIRCULATION BOILING AND THEIR APPLICATION TO BOILING REACTOR PERFORMANCE. P. A. Lottes, J. F.

Marchaterre, R. Viskanta, J. A. Thie, M. Petrick, R. J. Weatherhead, B. M. Hoglund, and W. S. Flinn. 33p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A summary is given of the work carried out over the past few years in the field of experimental boiling fluid flow. The various apparatus tested are described, along with pertinent variables investigated in each test. The tests described cover natural circulation boiling at pressures up to 600 psia, and power densities up to 95 kw/liter. Both steam-water densities and steam-water friction factors, for boiling with uniform heat addition, were studied. Also included are: (1) a brief description of boiling instability tests using electrically heated elements; and (2) a summary of visual studies using air-water mixtures at atmospheric pressure. Design equations, and hydrodynamic and heat transfer design criteria for natural circulation boiling reactors are presented. Included are methods for calculating steam volume fractions and recirculating flow rates as functions of reactor power. Heat transfer equations are listed, compared, and discussed. Burnout limitations are discussed. The method for calculating recirculating natural circulation boiling reactors is based on modifications of the standard equations for single-phase flow. (auth)

Pumps

14758 A/CONF.15/P/2157

Argonne National Lab.. Lemont, Ill.

DESIGN AND OPERATION OF A 10,000 GPM D. C. ELECTROMAGNETIC SODIUM PUMP AND 250,000 AMPERE HOMOPOLAR GENERATOR. R. A. Jaross and A. H. Barnes. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A pump-power supply combination in a compact single unit with the ability to pump highly radioactive sodium (10^8 Mev/(cm^3) (sec)) at high temperature (800°C) is described. The unit components are aligned vertically to reduce the electrical conductor length between homopolar generator and pump. The entire structure, including the 1250-hp drive motor, is 30 ft high and weighs 35 tons. The pump is designed to develop a head of 75 psi at a pumping rate of 10,000 gpm. At this rate the generator must deliver 250,000 amp at 2.5 v. The low-voltage requirement of the pump permits the use of flat sheet insulation of pure mica or ceramic. The pump is limited in temperature by the curie point of iron (763°C). The homopolar generator is of the liquid brush type: eutectic NaK serves as the current-conductor between the rotating and stationary members. There are no windings in the machine other than the 13-turn excitation coil of heavy copper strap. The essence of the pump-power supply unit lies in its ability to convert 2300-volt, 3-phase electrical power to controllable sodium pumping. Tests on the unit have revealed many interesting results which will aid greatly in the design of advanced models. (auth)

14759 A/CONF.15/P/2158

Argonne National Lab., Lemont, Ill.

CHARACTERISTICS AND PERFORMANCE OF 5000 GPM AC LINEAR INDUCTION AND MECHANICAL CENTRIFUGAL SODIUM PUMPS. Orville S. Seim and Robert A. Jaross. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Performance tests are being conducted on two prototype 5000-gpm sodium pumps for application in the primary and secondary heat transfer systems of the EBR-II. Both pumps, one electromagnetic and one mechanical, have operated more than 5500 hr in sodium at temperatures which have exceeded 800°F. The pump designs and test facilities are described. (auth)

Tracer Applications

14760 A/CONF.15/P/819

General Electric Co. General Engineering Lab., Schenectady, N. Y.

THE USE OF ACTIVATION IN MAKING ISOTOPE TECHNIQUES MORE AVAILABLE TO INDUSTRY. W. W. Schultz, H. D. Briggs, R. A. Dewes, E. E. Goodale, D. H. Morley, J. P. Neissel, R. S. Rochlin, and V. V. Verbinski. 26p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The industrial applications of the activation technique described include: the measurement of gear wear by activating wear particles in the lubricant, activation autoradiography, flow measurement by activation, die wear measurement by activation, induced line sources for position measurement, and activation in the foundry. (M.H.R.)

Waste Disposal

14761 A/CONF.15/P/1767

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.; Oak Ridge National Lab., Tenn.; and Du Pont de Nemours (E. I.) & Co. Savannah River Lab., [Augusta, Ga.].

EXPERIENCE IN THE DISPOSAL OF RADIOACTIVE WASTES TO THE GROUND. R. E. Brown, D. W. Pearce, W. de Laguna, E. G. Struxness, J. H. Horton, Jr., and C. M. Patterson. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Up to 12 years of practical experience in controlled waste disposal at the Hanford Works, the Oak Ridge National Laboratory, and the Savannah River Plant have provided a wealth of data on the feasibility of disposal of radioactive liquid waste at shallow depths in the ground. The disposal problems at the three sites are quite dissimilar since the environments are markedly different. The geologic and hydrologic conditions at the three sites indicated early in their history that at least small volumes of low activity level wastes could be discharged to the ground but that disposal of intermediate level materials demanded more detailed knowledge of the geology, microhydrology and soil chemistry. Determination of the waste behavior in the ground based upon laboratory research, field tests and the extensive use of monitoring wells provided the data permitting the safe disposal of many billions of liters of low to intermediate level waste at Hanford. At the Oak Ridge National Laboratory and the Savannah River Plant, similar earth sciences studies and field work have shown the inadvisability of ground disposal of high level radioactive liquids. Experience in the use of cribs, trenches, seepage pits, and swamps at Hanford and Savannah is discussed. (auth)

14762 A/CONF.15/P/1922

Argonne National Lab., Lemont, Ill. and Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

FLUIDIZED-BED CONVERSION OF FUEL PROCESSING WASTES TO SOLIDS FOR DISPOSAL. J. W.

Loeding, A. A. Jonke, W. A. Rodger, R. P. Larsen, S. Lawroski, E. S. Grimmett, J. I. Stevens, and C. E. Stevenson. 24p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Methods proposed or studied to convert liquid wastes to solid form, and the characteristics of solids which have been considered, are reviewed. A fluidized bed calcining process for safely and cheaply converting high level liquid wastes into solid oxides is under development. Experimental runs of up to several hundred hours' continuous operation were made with simulated inactive waste solutions in 6-inch diameter and 2-foot square calciners. Data were obtained under a variety of operating conditions. Studies include comparisons of heating electrically, by oil-fired tubes in the bed, and by transfer from heated liquid NaK metal in coils. Methods for the safe and economical storage of the calcined waste oxide are proposed. Calculations of heat generation due to fission product decay, and thermal conductivity measurements, were made to permit calculation of temperature distribution under various storage conditions. Studies of leaching out cesium and strontium activity show that long-term heat generation may thus be minimized and that the availability of strontium is markedly reduced. Some studies have been made of the stabilization of particles by the application of glazes. A preliminary cost study indicates the fluid bed calcination process may be economically advantageous, if conducted on an adequate scale, in comparison both with other methods for forming solids and with liquid waste storage methods. A demonstration facility to show the feasibility of producing solid wastes by calcination, and of storing solid wastes, is being designed for construction at the Idaho Chemical Processing Plant. (auth)

14763 A/CONF.15/P/2431

Scripps Institution of Oceanography, La Jolla, Calif.
and Inter-American Tropical Tuna Commission, La Jolla, Calif.

OCEANIC RESEARCH NEEDED FOR SAFE DISPOSAL OF RADIOACTIVE WASTES AT SEA. Roger Revelle and M. B. Schaefer. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Scientific problems underlying oceanic disposal of radioactive wastes on a large scale are outlined in the following sections: pollution hazards in confined waters through accidents to nuclear powered ships, fate of radioactive materials in coastal waters, deep ocean waters as a possible site for disposal of high level wastes, removal of radioactive materials from ocean waters by sedimentation processes, uptake and retention of radioisotopes by organisms used as food, effects of the biosphere on the distribution and circulation of radioactive elements, and the use of artificially radioactive substances in studying oceanic processes. (J.E.D.)

MINERALOGY, METALLURGY, AND CERAMICS

Ceramics and Refractories

14764 A/CONF.15/P/613

Los Alamos Scientific Lab., N. Mex.

DIFFUSION OF FISSION PRODUCTS AT HIGH TEMPERATURES FROM REFRACTORY MATRICES. George A. Cowan and Charles J. Orth. 15p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Data are presented for eighteen fission products in the temperature region 1500 to 2600°C. Loss rates in graphite range from zero for molybdenum at any temperature to greater than 20% per second for silver at 2400°C. Temperature dependences are obtained for these processes. The loss of gross fission product gamma activity from a 0.25 in. diameter graphite rod, simultaneously heated to 2600°C and bombarded for five minutes, was 70 to 80%. For simultaneous heating and bombardment, the loss of delayed neutron activity from graphite rods at 2400°C is 40% and, at 2600°C, 70%. Data are presented for zirconium, magnesium, and silicon oxide matrices. The use of diffusion properties to investigate short-lived fission products is illustrated with data for new isotopes. An effort is made to correlate diffusion data in terms of possible mechanisms. Some empirical mathematical relationships are presented. (auth)

14765 A/CONF.15/P/679

Oak Ridge National Lab., Tenn.

RADIATION STABILITY OF NONMETALS AND CERAMICS. J. H. Crawford, Jr. and M. C. Wittels. 27p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Recent studies in the United States of the effects of radiation on nonmetallic systems with potentiality for reactor applications are surveyed. In as much as structural integrity is one of the more important practical considerations, much attention has been given the extent and nature of changes in crystal structure and density of a wide variety of refractory inorganic solids after prolonged reactor exposure. Where possible, single crystals are used but in certain cases ceramic bodies and powders have also been examined in some detail. Significant recent results are the discoveries that in several systems a crystal structure transition into a higher energy phase occurs on exposures in excess of 10^{19} fast neutrons/cm^2. In one of these processes natural zirconia is converted from the monoclinic to the cubic phase (supposedly stable only above 1900°C) and in another, barium titanate transforms from the tetragonal to the cubic structure. Both of these transformed materials are stable to several hundred degrees centigrade. The mechanisms of such phase transformations are being studied. The main aim of the structure study program might be described as determining the roles that crystal structure and phase stability play in the extent of structural damage in the radiation environment of a reactor. Structural investigations have been supplemented in certain typical cases by measurements of radiation induced changes in hardness, thermal conductivity and elastic constants. In order to learn more of the nature of defects responsible for structural changes and loss of other desirable properties, investigations are being carried out on changes induced by reactor radiation in the electronic properties of simple, prototype nonmetallic systems. Optical absorption, magnetic susceptibility and paramagnetic resonance, properties which lend themselves to correlation with the nature of defects, have been investigated in some detail for several systems: silica, magnesia, alumina, and certain of the alkali halides. Another tool that has proved effective in studies of radiation induced defect structures is low temperature thermal conductivity. Both electronic properties and thermal conductivity indicate an inhomogeneous distribu-

tion of structural damage as a result of fast neutron bombardment. Studies have also been directed toward developing refractory fuel elements and shield materials. Thermally stable bodies containing uranium and thorium and refractory cladding materials are being evaluated with regard to structural integrity and fission gas retention in an attempt to develop elements which will operate at temperatures well above those to which current technology is limited by metallic fuels. (auth)

14766 A/CONF.15/P/1428
Battelle Memorial Inst., Columbus, Ohio.
CARBIDE COATINGS FOR GRAPHITE. J. M. Blocher, Jr. and I. E. Campbell. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A method of coating extended graphite surfaces with uniform, nonporous coatings of refractory carbides is discussed. Such coatings substantially increase the usefulness of this important high-temperature material. A vapor-deposition technique was developed which yields uniform, nonporous carbide coatings on extended surfaces. In this technique, the coatings are formed by simply heating the specimen to be coated in metal halide atmospheres at controlled pressures, with or without the use of a reducing agent such as hydrogen. The coatings produced by the controlled halide pressure technique have the appearance of fused carbides. Metallographic and x-ray examination of coated specimens show that the coatings are uniform and free of flaws. The coated specimens can be cycled thermally without cracking or spalling. Results of high-temperature corrosion tests are not yet available, but preliminary examination indicates that the coatings are superior to those produced by other methods. The techniques should be applicable in the formation of a wide variety of carbides on graphite and in the formation of other types of diffused coatings on other bases. (auth)

Corrosion

14767 A/CONF.15/P/699
Los Alamos Scientific Lab., N. Mex.
THE CORROSION BEHAVIORS OF PLUTONIUM AND URANIUM. James T. Waber. 31p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The many similarities in the chemical reactivity of plutonium and uranium were used to gain a deeper understanding of the mechanisms involved in the corrosion behavior of these metals and their alloys. It may be concluded that the reaction in aqueous environment is controlled by the rate of one or more reactions occurring at local anodes. The corrosion behavior of binary uranium alloys with zirconium, molybdenum, and hafnium, as well as ternary alloys with niobium and molybdenum, was studied to elucidate the role of moisture. Percentages of the order of 15 at. % are needed to affect significant improvements in the corrosion resistance. A cracking of the alloy specimens that is sometimes observed was related to the penetration and subsequent fracture of hydride needles which originate at the surface. Zirconium, aluminum, and thorium which are soluble in the face-centered-cubic delta modification of plutonium, reduce the rate of corrosion and render the plutonium relatively immune to attack by moisture. The observed rates for the better alloys are approximately equal in moist and dry air, and both rates are the same as that of unalloyed plutonium in dry air. (auth)

14768 A/CONF.15/P/714
Argonne National Lab., Lemont, Ill.
HIGH TEMPERATURE AQUEOUS CORROSION OF ALUMINUM ALLOYS. J. E. Draley, C. R. Breden, W. E. Ruther, and N. R. Grant. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

It has been shown that exposure of commercial aluminum alloys to water at elevated temperature results in intergranular attack and rapid deterioration. It was also shown that alloying aluminum with nickel and iron largely prevents this type of attack. Since that time a considerable amount of testing has been done at several laboratories, to determine in some detail the corrosion behavior of this type of alloy. The one that has received the most attention is alloy X8001, made by the addition of 1% nickel to American commercially pure metal (known as alloy 1100). Typical significant impurities are 0.5% iron, 0.1 to 0.3% silicon, and the order of 0.1% copper. As previously indicated the iron is a desirable constituent of alloy X8001. Efforts were made to develop other alloys with better corrosion resistance. A description is presented of the present state of progress in these objectives. Some of the results have been previously described; some are reported here for the first time. (auth)

14769 A/CONF.15/P/1430
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
THE USE OF ALUMINUM AS FUEL CLADDING IN HIGH TEMPERATURE WATER COOLED REACTORS. J. A. Ayres, R. L. Dillon, and R. J. Lobsinger. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Aluminum corrosion product solubility has been found to be an important factor in aqueous aluminum corrosion. High aluminum corrosion rates in dynamic tests, as compared to static test, can be accounted for in terms of oxide solubility. Hanford solubility measurements have established the solubility of aluminum corrosion product in the temperature range 200 to 350°C. Corrosion rates in dynamic systems have been successfully predicted on the basis of corrosion product solubility, sample area, and the rate of water refreshment. In the limiting case of very high water throughput and/or low sample area, however, the rate is not controlled by the oxide solubility. Instead the rate of corrosion depends on the rate of the dissolution process. Limiting (maximum) dissolution rates in deionized water have been determined at various temperatures between 200-350°C. Corrosion equations have been developed at HAPO to express the corrosion rate of aluminum in and out-of-reactor. The equations can be modified to express the corrosion rate of aluminum in either inhibited or moderately corrosive media such as Hanford process water. From these equations operating curves may be drawn which may be used to determine limits for the case of aluminum in water cooled reactors. (auth)

Geology and Mineralogy

14770 A/CONF.15/P/403
Woods Hole Oceanographic Institution, Mass. and Clark Univ., Worcester, Mass.
MARINE GEOCHEMICAL STUDIES WITH FALLOUT RADIOISOTOPES. V. T. Bowen and T. T. Sugihara. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The peaceful and military uses of atomic energy are resulting in the introduction to the world's oceans of new radioisotopes in significant amounts and of natural radioisotopes like C^{14} and H^3 in patterns and at rates different from those which have been previously obtained. In the Atlantic Ocean thus far significant additions have been made only by fall-out at the surface. Measurements in this system of the changing distribution of various radioisotopes are giving unique information on the relative importance of hydrodynamic, chemical, and biological processes in moving elements through the hydrosphere. On a large series of samples from varying depths in both North and South Atlantic Oceans we are measuring the concentrations of strontium 90, antimony 125, cesium 137, cerium 144, promethium 147, and carbon 14. Data on the Sr 90 of surface waters in middle latitudes of the North Atlantic show a persistent high variability among rather closely spaced samples. It is our tentative conclusion that this variability depends on the action of convective overturn of relatively large unit masses of water to permit retention of the effect of local high fall-out areas. As expected from this, much less variability has been found in the samples thus far processed from lower latitudes. The series of radioisotopes measured, selected originally for half-lives long enough to permit their accumulation in the oceans, represents elements of great variation in respect to their physical, chemical, and biological reactions in the sea. Thus we are able by measuring the ratios of the various isotopes at different depths to confirm hypotheses of the relative importance of water movement, sedimentation, and biological activity in vertical circulation of elements, and also to measure the rates at which these processes operate in various ocean areas. (auth)

14771 A/CONF.15/P/411

Princeton Univ., N. J.

TRACE ELEMENTS AND TRANSPORT RATES IN THE OCEAN. James R. Arnold. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The distribution in the sea of biologically active substances, such as oxygen, phosphorus, nitrogen, and silicon, gives some information on mixing and transport rates in the ocean. Naturally radioactive species such as carbon-14 and radium have given much new information in recent years. It is a difficult matter to define mixing and transport times in the sea as a whole, or even to determine whether the major turnover is steady or catastrophic in nature. However, the data support a value of a few hundred years for the time in which a tracer, injected at a single point, would become vertically and horizontally distributed throughout the ocean, or at least each major basin. Goldberg and Arrhenius have defined the residence time for elements in the ocean as $T = (A \ln 2)/(dA/dt)$, where A is the inventory of the element in the sea, and dA/dt the rate of introduction. In steady state, the rate of removal (including radioactive decay) is the same. T has a simple meaning under the following conditions: (1) the inventory in the sea is small compared with that in the sediments, (2) dA/dt has not changed in times of the order of 3T, and (3) the element is carried in and removed chiefly by a single mechanism. The first two conditions, defining a steady state, exclude the major constituents such as Na and Cl. The third is never met really well, since some material is carried in mechanically, in a form resistant to chemical attack, while other material is carried in in true solution, or in a readily available condition. If these two forms are distinguishable and do not undergo exchange, we can define separate half-lives T_d and T_s, the former for the element in detrital form, the latter for the element in true solution, and in forms rapidly exchangeable with it. For some elements this situation is probably closely enough approximated for the definitions to be useful. Complications such as return of ions from the ocean sediments to solution (which seems to occur for radium), and submarine volcanic activity, must also be considered. In this model T_d should be of similar magnitude for almost all elements. If T is calculated according to Goldberg and Arrhenius, T_d may be of the order of decades. Two statements can be made from a table of values of T_s. First, elements for which $T_s > 10^4$ years should be present in uniform concentration in almost all parts of the sea. If $T_s \sim 10^2$ years or less, the concentration should be highly variable. Second, if T_s is large it is very difficult for sudden changes of conditions (e.g., at the onset of a glacial period) to affect the concentration of the element in the sea. Thus if a change of concentration of such an element occurs in a sediment, the cause must be sought elsewhere. Uranium is an example of a long-lived species to which these considerations apply. Trace element studies should thus be valuable in measuring mixing and transport rates. However, nearly all older analyses are of unsatisfactory accuracy, failing among other things to separate dissolved species from others properly. Isotope dilution, activation analysis and other modern techniques help us to meet the exacting requirements. The author's work on beryllium analysis in sea water at levels below 10^{-12} parts per part is described as an example. (auth)

14772 A/CONF.15/P/412

Princeton Univ., N. J.

BERYLLIUM GEOCHEMISTRY AND BERYLLIUM-10 AGE DETERMINATION. J. R. Merrill, M. Honda, and J. R. Arnold. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An analytical method for Be was developed, based on a method of Adam, Booth, and Strickland, and using isotope dilution with Be^7 to determine the chemical yield in the analysis of standard igneous rocks and sediments. The Be content of a series of deep and surface sea water samples was determined to be about 10^{-7} ppm. The analytical procedure is described, and a model for computing the Be^{10} age measurement is presented. (J.R.D.)

14773 A/CONF.15/P/768

Columbia Univ., New York.

CRITERIA OF HYDROTHERMAL EMPLACEMENT IN PLATEAU URANIUM STRATA. P. F. Kerr. 12p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The uranium province in the western cordillera of the United States embraces portions of eight states: from the Dakotas on the northeast to Arizona on the southwest. Sedimentary strata which underlie this region contain hundreds of uranium deposits associated with areas of uplift. Major production comes from the part of the province which has long been recognized as the Colorado Plateau. Opinions differ concerning the mechanism involved in the emplacement of Plateau ores, and four hypotheses now receive support: (1) the circulatory groundwater theory, (2) the ash-leach theory, (3) the syngenetic theory, and (4) the hydrothermal theory.

Recent evidence supports primary uranium emplacement by hydrothermal solutions. Yet certain aspects of other hypotheses merit careful consideration. Criteria applicable in particular to the hydrothermal theory are outlined, and evidence relevant to other interpretations is considered. (auth)

14774 A/CONF.15/P/769
Geological Survey.
DISTRIBUTION OF URANIUM IN THE VOLCANIC ROCKS OF THE SAN JUAN MOUNTAINS, SOUTHWESTERN COLORADO. Esper S. Larsen, Jr., David Gottfried, and Marjorie Malloy. 11p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

There are about six major groups of volcanic rocks in the San Juan region, separated by extensive erosion intervals, and each of the main groups is divided into several subgroups, separated by a sharp break in lithology or by an interval of erosion. The rocks range from basalts and trachydolerites to rhyolites. The predominant rock type is dark quartz latite; light colored quartz latites and rhyolites are nearly as abundant. Uranium analyses have been made on 115 samples of these rocks. The trachydolerites carry approximately 1.3 ppm of uranium which is about the average, or a little higher than the average for such rocks. The uranium content of the dark quartz latites ranges from 2.2 to 3.0 ppm which is high for such rocks. The light quartz latites have a uranium content of about 3.6 ppm and the rhyolites 5.8 ppm of uranium. This amount is close to the average content for such rocks, and is comparable to that in the more siliceous intrusive rocks of the southern California batholith. The weighted average of rock in the area is 2.9 ppm of uranium, a little higher than in granitic rocks in the Sierra Nevada batholith. Study of the distribution of uranium in the different minerals of a rhyolite containing 6.6 ppm uranium showed that more than 90 percent of the uranium is in the groundmass. Although the accessory minerals, zircon and sphene, are relatively high in uranium content (800 to 71 ppm, respectively) they are present in amounts too small to contribute significantly to the total uranium content of the rock. (auth)

14775 A/CONF.15/P/770
Geological Survey, Menlo Park, Calif.
GEOLOGY OF THE ROSS-ADAMS URANIUM–THORIUM DEPOSIT, ALASKA. E. M. MacKevett, Jr. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Ross-Adams uranium–thorium mine near Bokan Mountain, Prince of Wales Island, Alaska, was found during May 1955 with an airborne Geiger counter. Mining commenced during the summer of 1957 subsequent to extensive exploration by diamond drilling. The 1957 production was about 15,000 tons that contained approximately 0.80 percent U_3O_8. The Ross-Adams deposit forms a crudely fusiform body that trends north and has surface exposures over a length of about 180 feet and an average width of 40 feet. Its depth as disclosed by diamond drilling and mining is approximately 60 feet. Near its southernmost exposures, the ore body is downthrown on the south by two steep, eastward-trending faults. Most of the ore body is flat lying; local steep plunges are drag effects of the faulting. The maximum extent of the ore body south of the eastward-trending faults has not yet been delineated. The core of the lode contains about 0.80 percent U_3O_8, and is surrounded by an aureole 5 to 10 feet thick that has a U_3O_8 content between 0.1 and 0.5 percent. The ore is slightly richer in thorium than in uranium. Uranoan thorianite and urano-thorite are the chief ore minerals. Coffinite has been questionably identified, and five secondary uranium minerals occur in minor amounts in near-surface environments. The deposit is red brown—largely an effect of its constituent hematite—and it contrasts sharply in color with the light-gray to white alkali granite host rock. A combination of two processes is postulated for the origin of the deposit. These are a small concentration of urano-thorite, a widely scattered minor accessory mineral in the alkali granite, at the site of the deposit, and, subsequent hydrothermal activity that formed numerous uraniferous veinlets throughout the deposit. Probably the eastward-trending faults acted as feeder channels for the hydrothermal solutions as they are locally mineralized besides also having post-ore movement. The veinlets contain uranoan thorianite along with calcite and hematite, and minor amounts of fluorite, quartz, pyrite, and galena. Commonly they are only a few millimeters thick and trend irregularly. As yet the major controlling factors that caused the concentration of urano-thorite and the localization of the uranium-bearing veinlets are unknown. (auth)

14776 A/CONF.15/P/771
Geological Survey, Grand Junction, Colo.
GEOLOGY AND URANIUM–VANADIUM DEPOSITS OF THE SLICK ROCK DISTRICT, SAN MIGUEL AND DOLORES COUNTIES, COLORADO. Daniel R. Shawe, Norbert L. Archbold, and George C. Simmons. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Sedimentary rocks known in the Slick Rock district in southwestern Colorado range in age from Devonian(?) to Cretaceous, and aggregate about 13,000 feet in maximum thickness. Important uranium–vanadium production has come from deposits in the Salt Wash member of the Morrison formation of Late Jurassic age. Detrital hematite, magnetite, and ilmenite in rocks of the Morrison formation not affected by epigenetic alteration contain appreciable amounts of several of the elements found in the ore deposits. Epigenetic alteration processes have bleached large volumes of rock and largely destroyed these minerals. Such alteration is spatially associated with the Dolores fault zone. Most of the known ore deposits are in the north part of the Slick Rock district in a belt called the Dolores ore zone. The zone lies along the Dolores fault zone but is wider than the fault zone. All known deposits are associated with abundant carbonaceous plant material. Uranium-vanadium deposits in the district are chiefly tabular to lenticular and are roughly parallel to the sedimentary bedding. Some ore bodies, however, are narrow, elongate, and curve sharply across bedding; these bodies have been called "rolls" by the miners. Mineral zoning is evident in some roll bodies; carbonates, geothite (altered from pyrite), selenides, and sulfides are commonly found in concentric layers at the concave edge of rolls. This zoning, and the relationship of roll ore bodies to sedimentary structures and lithology, suggest that ore was deposited at an interface between two solutions, possibly cool connate water and a warmer ore solution. On a district scale, copper and lead are distinctly most abundant in the ore deposits within and immediately adjacent to the Dolores fault zone, and less abundant in deposits toward the edge of the zone.

Uranium-vanadium deposits in the district occur only in sandstone that is considered to be epigenetically altered, and the most extensive epigenetic changes have occurred close to ore bodies. It is concluded that ground water, heated and set into circulation near the end of Cretaceous time by igneous intrusions in the La Sal and other centers on the Colorado Plateau, picked up elements from sedimentary rocks where they had been faulted and fractured, and deposited the elements at solution interfaces where accumulations of carbonaceous material provided favorable chemical conditions for precipitation. (auth)

14777 A/CONF.15/P/772
Geological Survey.
RADIOACTIVE DISEQUILIBRIUM STUDIES AS AN AID IN UNDERSTANDING THE NATURAL MIGRATION OF URANIUM AND ITS DECAY PRODUCTS. John N. Rosholt. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Several key daughter products and uranium must be determined in order to study disequilibrium in detail. Published radiochemical methods are used for the analysis of the isotopic abundances of Pa^{231}, Th^{230}, Ra^{226}, Rn^{222}, and Pb^{210}. Uranium is determined by the standard methods of analysis. In rocks which contain primarily the parent or daughter products of the Th^{232} series; Th^{232}, Th^{228}, Ra^{224}, and Bi^{212} are determined. Alpha scintillation measurements are used to resolve the abundances of each isotope present in the thorium, radium and bismuth–polonium separates. Repetitive counting measurements are made over periods of a few to several days. Four generalized types of radioactive disequilibrium involving the uranium series were found: (1) The deficiency of all daughter products, (2) the deficiency of Th^{230}, (3) the deficiency of uranium, and (4) the exclusive radium isotope occurrences. Several samples were analyzed which indicate that the time relationships can be estimated for the deposition of uranium. The samples for which the uranium deposition can be approximately dated must have ratios of Pa^{231}/U, Th^{230}/U, and Ra^{226}/U such that the growth of each of these isotopes from pure uranium would require approximately the same interval of time. The usual process involved with these dated relationships is uranium leaching from oxidized host rock and deposition in a reducing environment. Study of differences between routine radiometric assays and chemical assays for uranium is discussed, and the possibility pointed out that misleading conclusions may be obtained unless these occurrences are further investigated by radiochemical analyses. (auth)

14778 A/CONF.15/P/773
Geological Survey, Denver.
RADIOGENIC LEAD IN NONRADIOACTIVE MINERALS: A CLUE IN THE SEARCH FOR URANIUM AND THORIUM. R. S. Cannon, Jr., L. R. Stieff, and T. W. Stern. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Isotopic analysis of lead from nonradioactive minerals may provide a useful clue in the search for uranium and thorium. Many of the analyzed samples of sulfide minerals from uranium and thorium mining districts contain lead that is distinctive in isotopic composition compared with sulfides from districts producing other metals. The recognition of such isotopically distinctive radiogenic lead in galena, pyrite, or other nonradioactive ore minerals may be used as a helpful criterion in exploration for new uranium districts, or in searching for uranium or thorium in established metal-mining districts. The detection of radiogenic lead in nonradioactive minerals, however, should not be regarded as a self-sufficient exploration technique, although evidence of this kind may suggest proximity of uranium or thorium in areas where other evidence has not been recognized. Lead that is notably enriched in Pb^{206} evidently has been associated with uranium, in some geologic environment, past or present, in abnormal ratio. Such lead has been found in sulfide minerals from a number of uranium districts where deposits occur in clastic sedimentary rocks; in a number of uranium districts where uraninite occurs in veins; and in a single uraninite vein within a major nonferrous metal-mining district. Discovery of such lead in nonradioactive ore minerals in a locality where uranium deposits are not known may thus serve as a clue to justify an intensive search for uranium in that vicinity. (auth)

14779 A/CONF.15/P/774
Atomic Energy Commission, Washington, D. C.
RELATIONSHIP OF URANIUM ORE DEPOSITS TO PETROLEUM AND GAS-BEARING STRUCTURES. R. T. Russell. 16p. $0.50(OTS).

Prepared for the Second U. S. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In the United States, several uranium ore deposits are located on producing or breached oil and gas structures, or in the immediate vicinity of such structures. Individual deposits associated with these structures contain ore reserves which may exceed one million tons. Data derived from a study of the known deposits should be useful in evaluating the potentiality of other areas where similar structural relations and abnormal radioactivity are known to exist. Uranium deposits located in producing oil or gas fields include a deposit of more than one million tons of uranium ore on a single salt dome in Texas, and uranium deposits in the Poison Basin, Wyoming, which are situated over a producing natural-gas structure, having a potential of 100,000 to 200,000 tons. Important uranium mining districts are also located near producing oil fields or near structures which may have contained oil at some time in the past. The Gas Hills district in Wyoming is on the flanks of a breached anticline and within one mile of natural-gas seeps. Deposits in the Brown's Park formation near Maybell, Colorado, are within 10 miles of producing oil wells and natural-gas seeps are known within one mile of some of the uranium mines; and at Morrison, Colorado, uranium ore is associated with tar seeps. On the Colorado Plateau, large ore bodies with total reserves of at least 30 million tons of 0.3% U_3O_8 ore in the Ambrosia Lake district near Grants, New Mexico, contain "asphaltite." Mines in the San Rafael River Desert, Utah, are situated on breached oil structures and produce ore associated with "asphaltite." The uraniferous "asphaltite" ore at Temple Mountain, Utah has been known for nearly 50 years. At both Circle Cliffs and the Inter-River area in Utah, uranium ore is associated with asphaltic material on anticlinal structures. Many other deposits are on breached structures that may have contained oil or gas at one time. In Wyoming, uranium deposits in Tertiary sandstone and arkose generally lack carbon trash, but are located near oil or gas structures that contain hydrocarbons and natural gases capable of precipitating uranium. Also, many uranium deposits on the Colorado Plateau have insufficient plant remains present to be the fixing agent for uranium, but petroleum and/or natural gas are pro-

posed as possible extractants. The hydrogen sulfide contained in natural gas or dissolved in oil-field water has been a factor in the formation of some uranium deposits. Oil-type structural traps must have been effective in localizing both petroleum and uranium ore in some districts. Although petroleum may contain small amounts of uranium, it is doubtful if either oil or natural gas are important transporting agents for uranium. Careful consideration of these various factors will provide a basis upon which to evaluate more effectively many ore producing areas. (auth)

14780 A/CONF.15/P/775
Atomic Energy Commission, Washington, D. C.
LOW-LEVEL AERIAL RADIOMETRIC SURVEYING IN THE USA. T. L. Boyle. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

To help meet the urgent demand for uranium, airborne radiometric techniques were developed. Increasingly sensitive radiation detection instruments were devised and tested in light aircraft flying at low levels (20 to 100 feet), in heavier aircraft at higher levels (500 to 1500 feet), and in helicopters. After considerable testing, the Atomic Energy Commission selected a light, tandem seat, two-place aircraft, with pilot and geologic observer for crew, as being the most economical and practical approach to direct discovery of uranium deposits from the air. Private industry quickly supplemented airborne parties with their own aircraft, and an unprecedented search began. Vast areas in the Western United States were surveyed quickly; 1130 anomalies were discovered by government field crews and many additional anomalies by private industry. Anomalies discovered by government aircraft were published monthly and private air and ground parties quickly investigated them. It is interesting to note that outstanding results were obtained in the discovery of sedimentary-type deposits, but no significant vein-type deposits were found. In considering the advisability of undertaking an airborne radiometric survey program, both geologic and management problems must be judged. If, after considering all the problems, airborne radiometric surveying is undertaken, there is a good chance that a much better evaluation of the uranium potential of a region or country will be obtained. (auth)

14781 A/CONF.15/P/776
[Division of Raw Materials,] AEC.
APPLICATION OF ISOTOPIC DATA TO PROBLEMS OF URANIUM GEOLOGY. Hans H. Adler. 11p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The extension of isotopic analyses of lead to various secondary minerals formed in the zone of oxidation of ore deposits is suggested as a geochemical prospecting technique for uranium. The gross geochemical redistribution of radiogenic lead and associated radioactive nuclides is considered. Also, the origin of urano-organic matter as well as sulfides and sulfates associated with uranium ores is briefly discussed, and reference is made to the use of the isotopic pairs C^{12}/C^{13} and S^{32}/S^{34} to gain further insight regarding the genesis of carbon and sulfur in these materials. (auth)

14782 A/CONF.15/P/778
Geological Survey, Denver.
RADIUM AND URANIUM IN GROUND WATER OF THE UNITED STATES. R. C. Scott and F. B. Barker. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The normal "background" concentrations of radium and uranium in water from some of the principal water-bearing formations were evaluated for 486 samples collected from places throughout the United States. The evaluation was expressed in two ways: the actual concentrations found in the samples, and a concentration ratio—the ratio of uranium (in parts per billion) and radium (in micromicrocuries per liter) to the dissolved-solids concentration in each sample. The medians and ranges of the concentrations and concentration ratios are shown for each geotectonic region. The concentrations of radium and uranium occurring naturally in ground water are determined by the physical and chemical characteristics of the water and the availability of the elements in the rocks through which the water has passed. Inferences concerning the geochemical cycles of these elements are drawn from their concentrations, the chemical characteristics of the water, and the geology of each geotectonic region. A threshold of significant concentration is suggested for hydrogeochemical prospecting in each geotectonic region. (auth)

14783 A/CONF.15/P/780
Geological Survey, Washington, D. C.
GEOCHEMISTRY OF URANIUM IN ORGANIC SUBSTANCES IN PETROLIFEROUS ROCKS. A. P. Pierce, J. W. Mytton, and P. R. Barnett. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Detailed geochemical studies were made of the uranium-bearing organic mineraloids from several dozen localities in the United States and other countries. The materials studied occur as epigenetic impregnations and nodules in sedimentary host rocks which range in age from Precambrian through Tertiary and represent chiefly marine and fluvial environments of deposition. Uranium is present in these materials largely as uraninite although coffinite is present also in some localities. Thorium, where present, occurs in thorite. Uranium, lead, and lead isotope analyses indicate that the lead content is largely of radiogenic origin. X-ray studies show the presence of poorly oriented graphitic carbon and other diffuse diffraction bands that are interpreted as due to the presence of aliphatic bonds. Additional studies indicate that the amount of graphitic carbon, the C/H ratio, and the refractive index of these substances increase systematically with the total radiation flux which they have undergone. The large changes that occur in these parameters provide new criteria for determining the absolute age of these types of materials by radioactivity methods. Comparison of the x-ray data, refractive indices, and organic analyses of the uraniferous organic mineraloids with similar data on other naturally occurring organic substances suggests that the uraniferous mineraloids are derived from surface-active and water soluble organic substances present in petroleum and petroleum waters. (auth)

14784 A/CONF.15/P/862
Division of Raw Materials, AEC.
GEOLOGIC DISTRIBUTION OF NUCLEAR RAW MATERIALS. Robert D. Nininger. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Of the many metals needed for the industrial utilization of atomic energy, the ores of four—uranium, thorium, beryllium, and zirconium—have special significance as nuclear raw materials. They are listed in order of importance and in inverse order of availability and geologic knowledge of their occurrence at the

beginning of the atomic age. Exploration for uranium has been more intensive than for the other nuclear raw materials because of its greater importance and initial short supply. Rapid development of new supplies and a great advance in knowledge of uranium geology have resulted. The demand for thorium for atomic energy purposes has so far been almost entirely restricted to quantities needed for research and development. Consequently, exploration and advance in thorium geology have been limited. Beryllium and zirconium ores had substantial commercial uses prior to the advent of atomic energy and existing sources of supply have proven adequate for atomic energy requirements as well. Unlike uranium, utilization of these materials for atomic energy has been primarily a metallurgical problem rather than a problem of raw material supply, and intensive exploration programs have not been required. (auth)

14785 A/CONF.15/P/1770
Geological Survey, Denver.
GEOLOGY AND RESOURCES OF BERYLLIUM IN THE UNITED STATES. J. J. Norton, W. R. Griffitts, and V. R. Wilmarth. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Beryl is obtained from relatively small mines and has been concentrated only by hand-sorting. Flotation with petroleum sulfonate is a promising future method of concentration. Other beryllium minerals that have been marketed are chrysoberyl and bertrandite. Helvite is a potentially valuable mineral in some contact metamorphic deposits. Beryllium has also been detected as a minor constituent of many rock-forming minerals. Beryllium is concentrated with alkalies and volatiles in rocks belonging to the late phases of magmatic processes. A few granites and feldspathoidal rocks contain as much as 0.01 %. Higher concentrations occur chiefly in granitic pegmatites, but are also in a few contact metamorphic deposits and quartz veins. In zoned pegmatites beryl may appear in several units, but ordinarily it is most abundant in some single zone. It is richest in outer zones containing quartz, plagioclase, and muscovite; in intermediate zones containing quartz and plagioclase with or without muscovite, perthite, amblygonite, or spodumene; and in zones that are contiguous to quartz cores. The very large bodies of spodumene-rich pegmatite in the tin-spodumene belt of the Carolinas contain approximately 0.4 % beryl. A beryl-quartz vein has been mined at Lake George, Colorado. Beryl also appears in other quartz-rich veins, especially those that contain tungsten and tin. A few tactite deposits in the western states contain beryllium in helvite, commonly accompanied by fluorine and tungsten. Known pegmatite deposits in the United States with 1.0 % or more beryl have reserves of approximately 9,000 tons of beryl. Lower grade deposits with 0.2 to 1.0 % beryl, mostly in the tin-spodumene belt of the Carolinas, contain at least 200,000 tons of beryl. (auth)

14786 A/CONF.15/P/1772
Bureau of Mines.
ZIRCONIUM RAW-MATERIAL SUPPLY. F. W. Wessel. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

While zirconia is a significant constituent in 29 minerals, the zircon group is the principal material of commerce. Three deposits in Florida produce 90% of the domestic total, the remainder coming from South Carolina. Deposits have been noted in 24 states and Alaska. Reserves of 7,500,000 tons can supply the domestic market for 100 years at the apparent 1956 consumption rate. Hafnium is present in all zirconium-bearing minerals. In zircon, Hf/Zr ratios are from 0.01 to 0.36. One pound of zirconium sponge, purified for atomic use, requires 3.87 pounds of zircon. The present estimated annual capacity of zirconium producers in the United States, principally in terms of reactor grade metal, is 2900 tons. This would require 11,500 tons of zircon, or $\frac{1}{9}$ of the estimated supply available in the United States during 1957. Australia leads in the production of zircon, and with the United States, accounts for over 90% of the world's production; small amounts are produced in Africa and South America. During 1957, nearly half of Australia's production was shipped to the United States. (auth)

14787 A/CONF.15/P/1904
Geological Survey, Denver.
GEOLOGIC APPRAISAL OF URANIUM RESOURCES OF THE UNITED STATES. Arthur P. Butler, Jr. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The uranium resources of the United States are in four principal geologic environments: terrestrial sedimentary rocks, veins, marine phosphorites and shales, and igneous rocks. These resources include material of ore grade and lower grade. Because discovered deposits constitute only a part of resources, an appraisal of resources requires application of geologic principles to the study of (1) uranium deposits and districts that are incompletely explored, and (2) geologically favorable areas that may contain undiscovered uranium. (auth)

14788 A/CONF.15/P/1906
Geological Survey, Grand Junction, Colo.
URANIUM DEPOSITS OF THE SOUTHERN PART OF THE SAN JUAN BASIN, NEW MEXICO. L. S. Hilpert and R. H. Moench. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Uranium ore reserves of the southern part of the San Juan Basin total 52 million tons, averaging 0.26% U_3O_8. These reserves constitute 80% of the total in the Colorado Plateau and 70% of the United States total. Nearly all of these reserves are in the southern part of the San Juan Basin, McKinley and Valencia Counties. This area probably also contains many millions of tons of potential reserves. (auth)

14789 A/CONF.15/P/1907
Geological Survey.
GEOLOGIC EVALUATION OF AIRBORNE RADIOACTIVITY SURVEY DATA. Robert M. Moxham. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The development of large-volume crystal detectors and the application of semiquantitative analytical techniques now permit geologic evaluation of regional surveys. The methods used are discussed and applied to specific data obtained by the Geological Survey. (D.E.B.)

14790 A/CONF.15/P/1908
Geological Survey, Salt Lake City.
INCREASING THE EFFICIENCY OF EXPLORATION DRILLING FOR URANIUM BY MEASUREMENT OF RADON IN DRILL HOLES. Allan B. Tanner. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Through the influence of atmospheric pressure changes radon-222 tends to migrate from uranium ore into drill holes. Under appropriate geologic conditions advantage may be taken of this tendency by increasing the distance between exploration drill holes without increasing the likelihood of missing bodies of ores. Where there is sufficient fracturing or permeability of the rock constituting the ore horizon, anomalous concentrations of radon may be observed tens of feet from uranium ore, in contrast to the extremely local information derived from gamma-ray logs or from analysis of drill cuttings or cores. If there are errors, caused by excess radon, in gamma-ray evaluation of many drill holes in an area, there is reason to believe that this method is applicable. Radon measurement may be accomplished either upon samples of drill-hole air taken at the ore horizon or by direct measurement of alpha radiation in the hole. Samples of air from the ore horizon in eleven drill holes on a line traversing a uranium ore body in limestone near Grants, New Mexico, were analyzed for radon with field equipment. Anomalous concentrations of radon were observed not only in samples from holes that penetrated ore but also in samples from holes that penetrated rock containing only trace quantities of uranium and that were located from one to two hundred feet from the nearest ore. (auth)

14791 A/CONF.15/P/1909

Geological Survey, Denver.

DEVELOPMENTS IN RADIATION DETECTION EQUIPMENT FOR GEOLOGY. W. W. Vaughn, V. C. Rhoden, E. E. Wilson, and R. H. Barnett. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A new instrument that will scan a moving train of drill core for radioactivity was constructed and tested. The instrument now in use by the U. S. Geological Survey will accept drill cores from 1 to 3 in. in diameter by way of a continuous conveyor belt and will provide a permanent record of radioactivity as a function of drill core length. It may be used with equal effectiveness, when properly calibrated, to analyze crushed sample material in cylindrical cardboard containers. The sensitivity of the instrument is such that a variation in uranium content of 0.01% will give a corresponding change of 50 counts per second in the recorded counting rate. Semiquantitative results may be obtained from sample material ranging as low as 0.005% U. TIDE (Time Interval Differentiator, Electronic) is an electronic circuit capable of sorting paired pulses into either of two channels, depending upon the time interval between members of the pair. The device also counts the total number of pulses considered by each circuit. The instrument was developed as an aid in measuring thoron and action in the presence of radon by means of an alpha counter. An instrument for simultaneously measuring alpha and gamma activity in small (two-inch) bore holes was designed to assist the study of radon contamination in drill holes. (auth)

14792 A/CONF.15/P/1910

Pennsylvania State Univ., University Park. Coll. of Mineral Industries.

MINERALOGY AND CHEMISTRY OF URANIUM-BEARING BLACK SHALES. Thomas F. Bates and Erwin O. Strahl. 7p. (NYO-7907). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The main objectives of the investigation are: to obtain a large amount of precise mineralogical, petrographic, and chemical data on many samples of black shale representative of various geologic periods, geographic localities, and amounts of uranium concentration; to analyze and define the interrelationship between the numerous measured variables with respect to differences between geologic and geographic units within each shale studied and differences between shales; and to interpret the results in the light of present concepts with the hope of adding new information in such areas as the mineralogical and chemical nature of black shales, the relationship of uranium and other trace elements to the major constituents and to the petrographic characteristics of the rocks, the interrelationships of organic and inorganic matter, and the geological conditions which lead to the formation of these rocks and the concentration of uranium in them. (auth)

14793 A/CONF.15/P/1911

[Division of Raw Materials, AEC.]

URANIUM DEPOSITS IN THE PRYOR-BIG HORN MOUNTAINS, CARBON COUNTY, MONTANA, AND BIG HORN COUNTY, WYOMING. Olin M. Hart. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Uranium deposits in the Pryor-Bighorn Mountains of Carbon County, Montana and Big Horn County, Wyoming, U. S. A., occur in the Madison limestone of Mississippian age. This district forms part of the northern rim of the Big Horn Basin in norther Wyoming and south-central Montana. Structurally the area is a compound uplift consisting of numerous asymmetric anticlines and monoclines, several of which are faulted. These structures were formed during the Laramide orogeny by recurrent movement along zones of weakness within the Precambrian complex. The uranium deposits are located in karst topography in caves, sheet breccias, and silt and clay fillings of the karst caverns. The fill material is insoluble residue from solution of the limestone and silt in beds overlying the Madison limestone. The ore mineral is tyuyamunite and metatyuyamunite, closely associated with crystalline calcite. These minerals were deposited together in ponded waters within caverns, in silt and clay fillings, along walls of open solution joints and water-courses, and through parts of the prominent solution breccia forming the floor of cavern development. Most deposits contain from a few tons to 500 tons, although a few range up to 8,000 tons. The ore bodies conform to the size and shape of the cavern or solutional form in which they occur. The tenor of the ore is high, usually exceeding 0.50% U_3O_8, with some ores assaying as high as 4.0% U_3O_8. The V_2O_5 content is 20 to 40% higher than uranium. Associated minerals in ores are calcite, limonite, hematite, barite, various clay minerals, and locally gypsum, fluorite, and celestite. The exploration problem in this district consists of locating the courses or channels of the mineralizing solutions through the complex "plumbing system" of the karst topography and finding the filled or plugged caves containing mineral concentrations. (auth)

14794 A/CONF.15/P/1912

Atomic Energy Commission, Washington, D. C.

RELATIONSHIP BETWEEN SANDSTONE-TYPE URANIUM DEPOSITS AND GROUND WATER IN SOME URANIUM-PRODUCING AREAS. W. C. Woodmansee. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Comprehensive ground-water studies are of value in exploration for uranium in districts where ore bodies occur in zones of water tables or in water-bearing host rocks and where circulating ground waters are considered the major ore solutions. In such districts, zones of water tables are favorable for uranium deposition, whether shallow, as in Tertiary basins of Wyoming, or deep, as in the Ambrosia Lake area of New Mexico; ground-water courses are affected by structural features which may act as ore controls; and directions of ground-water migration indicate possible projections or extensions of ore bodies associated with ground-water movement. (auth)

14795 A/CONF.15/P/1917
Bureau of Mines, Denver.
UNDERGROUND URANIUM MINING ON COLORADO PLATEAU. W. L. Dare. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The size and continuity of the Chinle ore bodies in the Big Indian district, Utah, have permitted mine operators to plan a more integrated development and mining system using larger and more specialized equipment. Thick ore and firm backs at the south end of the district has permitted room and pillar mining, using large drill jumbos and diesel-powered haulage equipment. The Gismo loader and draw-chute system has proved efficient. Driving the haulage-way below the stope level is an advantage when pillars are recovered. To the north, thinner ore with weaker backs favor retreat systems and smaller equipment. Here, the ore bodies are delineated by a grid system of drifts, and the ore recovered by panel, longwall, or similar mining methods, retreating toward the principal entry. Labor productivity ranges from 8 to 20 tons per man-shift, and direct mining and development costs, excluding initial development, ranges from $5.75 to $7.50 per ton. A unique system of mine development is in the Temple Mountain district, Utah, where the shallow Chinle deposits are mined through 36-inch diameter calyx drill holes. Using small diesel-powered ore buggies and bucket hoisting, ore is produced from the two largest mines at a rate of 4.1 tons per man-shift, at a direct cost of $7.05 a ton. Ambrosia Lake deposits range from 5 to 80 feet thick and occur from 350 to 1,000 feet below the surface. These mines are in development stages. Open, retreat, and top-slice stoping is planned. Adequate ventilation is essential in uranium mining since sufficient air must be coursed through the workings to maintain airborne radioactive concentration at tolerance levels and dilute exhaust gases where diesel-powered equipment is used. Uranium miners have found that radiometric scanning is a quick and efficient method for checking the grade of the ore produced and in process of development. (auth)

14796 A/CONF.15/P/1919
[Division of Raw Materials, AEC.]
OPEN-CUT MINING OF URANIUM ORE IN THE WESTERN UNITED STATES. D. D. Baker, R. H. Toole, F. A. Bemis, D. R. Hill, and R. A. Lindblom. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Cost of mining by open pit is influenced by many factors such as type of deposit, amount and type of overburden, and scale of operations, and may range from $4.80 to $11.00 per ton of ore. By comparison, the cost range for underground mining is between $8.25 and $38.00. Other advantages of open-pit mining are lower working force requirement, greater safety, elimination of ground support and ventilation problems, more complete extraction, greater opportunity for selective mining and grade control, and the recovery during stripping of small isolated ore blocks not suitable for extraction by underground methods. Examples of uranium mines employing open pit methods in the United States include: the Jackpile and Haystack Mountain mines in northern New Mexico, the Monument No. 2 mine and the Cameron area mines in northern Arizona, the Rattlesnake and Happy Jack mines in Utah, the Lucky Mac and Vitro mines in Wyoming, and the Dawn mine in Washington. Each of these mines and the equipment used are described. Cost data on various phases of open-pit mining are included and comparative costs are discussed. (auth)

14797 A/CONF.15/P/1920
Atomic Energy Commission, Washington, D. C.
GAMMA-RAY LOGGING TECHNIQUES IN URANIUM EVALUATION. R. F. Droullard and P. H. Dodd. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The most satisfactory method for determining the over-all resolving time for gamma-ray logging units is the one using the chart-summation procedure for quantitative assaying. The use of the procedure in determining resolving time is described. (J.E.D.)

14798 A/CONF.15/P/1921
Division of Raw Materials, AEC.
RESOURCES OF NUCLEAR FUEL FOR ATOMIC POWER. J. C. Johnson. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Recorded uranium ore reserves in the United States have more than doubled since 1955, and now are estimated to contain 200,000 tons of uranium. Full development of present producing areas may nearly double this figure. Figures released by the Canadian and South African Governments indicate uranium reserves of about 400,000 tons in each of those countries. Reserves in Australia, Belgian Congo, France, Portugal, and other Western Nations may approximate 150,000 tons. Total uranium reserves in countries other than the USSR and areas of Soviet influence may therefore be currently estimated at about 1,300,000 tons. This figure represents an increase of about 800,000 tons since 1955. Discovery of an additional 2 million tons of low-cost uranium is probable in extension of present producing areas and in areas of similar geology. At the present time, uranium production is sufficient for all contemplated nuclear power requirements and other peaceful uses. However, future nuclear power programs may require as much as 50,000 to 100,000 tons of uranium a year by 1970 or 1975. Uranium exploration and developement must continue in order to assure an adequate supply. (auth)

14799 A/CONF.15/P/1931
[Grand Junction Operations Office. Exploration Div.], AEC.
LITHOFACIES OF CONTINENTAL SEDIMENTARY ROCKS RELATED TO SIGNIFICANT URANIUM DEPOSITS IN THE WESTERN UNITED STATES. W. S. Keys and P. H. Dodd. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A study of uranium deposits and districts in the USA suggests certain consistent relationships between features of the sedimentary host rocks and uranium ore. In the USA, most uranium deposits occur in continental

sedimentary rocks ranging in age from Permian to late Tertiary. Approximately 95% of the ore reserves are in continental sedimentary rocks of the following ages: Triassic (6×10^6 tons of ore containing 23×10^3 tons of U_3O_8), Jurassic (57×10^6 tons of ore containing 148×10^3 tons of U_3O_8), and Tertiary (13×10^6 tons of ore containing 32×10^3 tons of U_3O_8). These ore reserves are distributed in a number of districts within which the individual deposits are similar geologically and have a maximum size characteristic of the district. The similarity of deposits in rocks of such diverse age suggests a similar mode of concentration of uranium. The deposits are generally considered to be epigenetic, regardless of the source of the uranium and associated metals. The geologic characteristics of some significant uranium districts are described. (auth)

14800 A/CONF.15/P/1932

[Division of Raw Materials,] AEC.

SUMMARY OF UNSOLVED PROBLEMS AND NEW TRENDS IN URANIUM GEOLOGY. D. L. Everhart. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Current trends in the study of uranium geology indicate widening areas of favorability for the occurrence of uranium ore deposits in many parts of the world. Continuing geochemical studies should increase our understanding and application of the concept of uranium provinces and sub-provinces. Further detailed petrographic and geochemical studies will more clearly define the complex behavior of uranium during magmatic differentiation. The increased application of hydrological studies to uranium geology would add much of value to a workable understanding of ore controls in continental sedimentary environments. Finally, combined geologic field and laboratory studies of natural precipitants of uranium are basic and must continue. These studies are necessary to assure the discovery of adequate uranium resources for the world's atomic-power development. (auth)

14801 A/CONF.15/P/1933

[Division of Raw Materials, AEC].

REGIONAL EXPLORATION CRITERIA FOR URANIUM. Jack Kratchman. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Examples are given which illustrate this type of exploration criteria and future reserve. In addition to new reserves from producing mines or districts, it is anticipated that other reserves will be developed in areas which lack significant discoveries but contain favorable geologic features. In Precambrian shields, uranium is almost invariably related to Archean or Proterozoic geosynclines and mobile belts. In some instances mineralization may occur in fault or breccia zones within these deformed Precambrian sediments or in associated silicic-alkalic-pegmatitic intrusives. However, the presence of locally exposed intrusives is not essential to the existence of a deposit. Post-Precambrian basins of sedimentation are becoming increasingly important in the distribution of deposits. Granitic rocks intruded in the later stages of geosynclinal development frequently act as host rocks for significant uranium deposits. Numerous uranium deposits are located in granites intruded into the Hercynian or Variscan folded structures of Central and Western Europe. Granitic intrusives are widespread in the Tertiary mountain belts of the world, and some commercial uranium deposits are related to these intrusives (Prince of Wales Island, Alaska; Spokane, Washington, U.S.A.; and Marysvale, Utah, U.S.A.). Future uranium provinces are discussed. Among those areas selected as being potentially favorable are regions in the Canadian, Australian, African, and Brazilian shields; the Tarim and Ordos Basins, Central Asia; the Texas Basin, U.S.A.; the Pannonian Basin, Hungary; Hercynian or Variscan granites, Europe (Vosges Mountains, France; Odenwald, Germany; Sardinia; and Corsica). (auth)

14802 A/CONF.15/P/1934

[Grand Junction Operations Office. Exploration Div.] AEC.

RELATION OF URANIUM DEPOSITS TO FEEDER STRUCTURES, ASSOCIATED ALTERATION, AND MINERAL ZONES. John W. Gabelman and W. H. Boyer. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Mineral districts in southwestern Colorado commonly contain a central altered area enclosed by irregular zones containing different metal deposits, including uranium. The central altered area is essentially a high-angle "pipe" which encloses a portion of a major fault zone, or an igneous contact, or is apparently not associated with any major structure. Alteration occurs in all rock types although it is selectively stronger in the metamorphic basement rocks and the intrusives of Tertiary age. Alteration, in paragenetic sequence, is commonly of the argillitic, sericitic, silicic, and pyritic types. In intensely mineralized districts, veins and replacement bodies occur principally marginal to the central, pervasively altered area, in ground altered only in the wall zones of larger fissures. Deposits within the central altered area are principally replacement disseminations. Types of metal deposits are generally grouped along preferred structural weaknesses according to distance from the central altered area. Each group defines a zone, partially concentric about a central area. The central alteration pipe is interpreted as the principal feeder channel for the district and represents the most permeable locality prior to mineralization. Early alteration products are believed to have sealed this permeable area near the surface, forcing later metallizing solutions from the central channel at depth to less permeable available marginal channels. Later solutions rose through successively more distant channels, unless inner channels were reopened or incompletely sealed. In the western Colorado metallogenic province uranium occurs within some central alteration pipes, possibly as a lattice constituent in iron sulfide. Deposits contain less than 100 tons of rock containing 0.03% U_3O_8. Uranium occurs in base-metal zones as pitchblende, commonly associated with copper. Here deposits are less than 100 tons of 0.1% U_3O_8 material. Commercial uranium deposits occur on the outer margin of the gold zone, where deposits may be about 50,000 tons of 0.5% U_3O_8 ore. Many alteration pipes in the southern Colorado Plateau enclose collapsed-breccia or collapsed-plug pipe structures which contain no volcanic material, but which are interpreted as cryptovolcanic structures. Many of these pipes are mineralized by uranium. Several, having a magnitude order of 30,000 tons of 0.5% U_3O_8 ore per pipe, are known. These pipes are interpreted as possible central feeder structures for districts where the ore is of hydrothermal origin. Such pipes may not only contain uranium deposits but may also have supplied laterally migrating solutions from which outlying sandstone impregnations were deposited. (auth)

14803 A/CONF.15/P/1935

[Division of Raw Materials. Geophysical Research and Development Branch], AEC.

SOME GEOCHEMICAL METHODS OF URANIUM EXPLORATION. C. T. Illsley, C. W. Bills, and J. W. Pollock. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Geochemical research and development projects were carried on to provide basic information which may be applied to exploration or general studies of uranium geology. The applications and limitations of various aspects of geochemistry to uranium geological problems are considered. Modifications of existing analytical techniques were made and tested in the laboratory and in the field. These include rapid quantitative determination of uranium in water, soil and peat, and of trace amounts of sulfate and phosphate in water. "Geochemical anomaly" has been defined as a significant departure from the average abundance background of an element where the distribution has not been disturbed by mineralization. The detection and significance of geochemical anomalies are directly related to the mobility of the element being sought in the zone of weathering. Mobility of uranium is governed by complex physical, chemical, and biological factors. For uranium anomalies in surface materials, the chemical factors affecting mobility are the most significant. The effects of pH, solubility, coprecipitation, adsorption complexion, or compound formation are discussed in relation to anomalies detected in water, soil, and stream sediments. (auth)

14804 A/CONF.15/P/1936

[Division of Raw Materials. Geophysical Research and Development Branch], AEC.

MULTIPURPOSE LOGGING EQUIPMENT FOR URANIUM EXPLORATION AND EVALUATION OF DEPOSITS. R. D. Casey, J. H. Scott, and E. M. Wescott. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Logging methods which have shown great promise are single-point electric logging (wet or dry), combined electric and gamma-ray logging, multielectrode resistivity logging, and caliper logging. An extended application of the single-point electric logging method has been developed. The new technique involves quantitative interpretation of the resistance log for either wet or dry holes by the use of departure curves. The theory, field techniques, equipment and operational costs, and application of this logging method are discussed. The combination logging of gamma-ray radiation and formation resistance simultaneously on a two-channel logger offers the unique advantage of direct comparison of lithology and mineralization. Equipment costs, probe specifications, operational techniques and applicability of combination logging are discussed. An experimental dry-hole probe with four pairs of vertically offset roller electrodes has been used to evaluate the multiple electrode dry-hole resistivity logging method. The theory, purpose, equipment, operational techniques, interpretation of results and costs are discussed. Caliper logging involves measuring the diameter of a drill hole versus depth. Examples of caliper logs are shown. (auth)

14805 A/CONF.15/P/1979

Scripps Institution of Oceanography, La Jolla, Calif.

A CRITICAL EVALUATION OF RADIOCARBON TECHNIQUES FOR DETERMINING MIXING RATES IN THE OCEANS AND THE ATMOSPHERE. Harmon Craig. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The geochemical cycle of natural radiocarbon is now fairly well understood and it is possible to outline in some detail the application of C^{14} data to natural mixing processes. From the observed distribution of C^{12}, C^{13}, and C^{14} in the atmosphere, biosphere, and sea, it is found that the exchange time of atmospheric carbon dioxide with the sea is about seven years. The problem of oceanic mixing is complicated, and the interpretation of the radiocarbon distribution in the sea depends greatly on the assumed characteristics of a model ocean. Two models which represent extreme cases are discussed; the relationship between mixing times for carbon and mixing times for water is different in the two cases, which probably bracket the average behavior of the oceans as a whole. (auth)

14806 A/CONF.15/P/1980

Scripps Institution of Oceanography, La Jolla, Calif. and California Inst. of Tech., Pasadena.

IONIUM–THORIUM AND LEAD ISOTOPE RATIOS AS INDICATORS OF OCEANIC WATER MASSES. Edward D. Goldberg, Claire Patterson, and T. Chow. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The ionium-thorium ratios and isotopic composition of lead in manganese nodules and in deep-sea sediments from the Pacific and Atlantic Oceans have been studied using alpha spectrometric and mass spectrometric techniques, respectively. The manganese nodules are concretionary accumulations of oxides of iron and manganese with appreciable concentrations of such trace metals as cobalt, lead, the rare earths, zinc, copper, nickel, and thorium. These deposits are unique to the deep-sea floor and the ferromanganese phases apparently form from chemical species in solution in oceanic waters. The deep-sea sediments analyzed in this study had as principal constituents clay minerals (mainly illites), detrital quartz and feldspars, biogenous opal, and phillipsite. Both the isotopic composition of the lead and the ionium/thorium ratios in surface samples from the sediments and nodules showed distinct variations between oceans and also possessed characteristic values for different localities within the Pacific Ocean. These results can be interpreted on the basis that the deep oceanic water masses, which are in contact with the sediment surfaces, furnish these isotopes to the sediments. The isotopic compositions of lead and thorium in these different circulating water masses probably reflect the previous histories of the waters in the accumulation and loss of products from the major sedimentary cycle. Such isotopic analyses in samples from the deep-sea floor can compliment the classical methods of study of deep-oceanic circulation which are based on the distribution of temperature and the concentrations of dissolved constituents in the water under consideration or on direct measurement of the velocities of the water masses. Further, the possibility of studying the character and behavior of deep oceanic waters in past ages presents itself in the depth distribution of these isotopes in deep-sea cores. Finally, the validity of rates of accumulation of deep-sea sediments based upon ionium/thorium ratios is considered. Two critical assumptions of the method are: the bulk of the ionium and thorium enter the sediments from a dissolved form in oceanic waters, and the ionium/thorium ratio in

seawater has been constant over the time period that is being studied. Certain aspects of the latter assumption are considered on the basis of residence times of elements in the oceans and the chemical and mineralogical compositions of deep-sea sediments. (auth)

14807 A/CONF.15/P/2019
Harvard Univ., Cambridge, Mass. and Geological Survey, Washington, D. C.
RECENT PROGRESS IN THE DESCRIPTIVE MINERALOGY OF URANIUM. Clifford Frondel and Alice D. Weeks. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The present knowledge of the descriptive mineralogy of uranium and thorium is reviewed, and a summary is given in tabular form. The leading problems remaining is the descriptive mineralogy of uranium and thorium are discussed. (W.D.M.)

14808 A/CONF.15/P/2410
THE NATURAL RADIUM IN THE OCEAN AS A TRACER. F. F. Koczy. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The deep ocean basins are being considered for disposal of radioactive waste. In order to evaluate this tracer studies of lateral and vertical mixing in the oceans are reviewed. That the radium which occurs naturally can be used for this is shown. (T.R.H.)

Metals and Metallurgy

14809 A/CONF.15/P/517
Ames Lab., Ames, Iowa and Iowa State Coll., Ames. Inst. for Atomic Research.
PYROMETALLURGICAL PROCESSING. Premo Chiotti and Adolf F. Voigt. 17p. (ISC-1018). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A brief review of the general methods used in the pyrometallurgical purification of liquid metals is given with special emphasis on recent work on the pyrometallurgical separation of fission products and plutonium from uranium and the separation of uranium from thorium. The use of thermodynamic data in estimating the effectiveness of various pyrometallurgical separations is considered. Those fission products which extract into silver, including the alkaline earths, rare earths, and others, can readily be removed from the silver layer by melting the latter with sodium chloride containing a small amount of silver chloride. The silver is thus recovered in good condition for reuse and the extracted material is concentrated. Extraction studies were made with silver on a U-0.2% Pu alloy to determine the behavior of plutonium in the system at this concentration. Other extractants, rare earths, and alkaline earths were also studied in extractions with this alloy. Relative to the problem of separating small amounts of uranium from thorium, the phases which exist in magnesium-rich magnesium-thorium-uranium alloys were determined. The solubility of uranium in magnesium, magnesium-16 wt. % thorium, magnesium-35 wt. % thorium and magnesium-45 wt. % thorium liquid solutions was measured. Various possible purification procedures for the removal of fission products from the thorium-magnesium solution or from the massive uranium obtained are considered. Thorium can be separated from magnesium by distillation of the magnesium. An alternate procedure wherein the thorium is precipitated as thorium dihydride was investigated. The major part of the thorium can be precipitated at 675°C and one atmosphere hydrogen pressure. Under these conditions the residual thorium content in the magnesium was found to be 8.1 wt. %. More complete separation can be obtained by lowering the temperature and/or increasing the hydrogen pressure. (auth)

14810 A/CONF.15/P/528
Los Alamos Scientific Lab., N. Mex.
TECHNIQUES FOR THE METALLOGRAPHY OF PLUTONIUM. E. M. Cramer and F. W. Schonfeld. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The equipment and procedures used for the preparation of plutonium-bearing metallographic specimens at the Los Alamos Scientific Laboratory are described and the adaptations of metallographic apparatus for polishing, etching, micrography, hardness testing, and heat treating to meet the peculiar needs of a plutonium laboratory are discussed. The use of gloveboxes is restricted to those operations in which discrete particles of metal or oxide are produced, such as cutting, grinding, and mechanical polishing. The boxes are arranged in trains, with each train having a hood at one end through which specimens enter and leave the system. The average metallic sample contains only a few grams of plutonium, and specimens are usually mounted by potting with a liquid resin, although bakelite or other mounting material may be used occasionally. The mounted sample is mechanically polished, in a glovebox train, and electropolishing and electroetching have been used extensively, especially for pure plutonium and plutonium-rich alloys. Handling is done with forceps, and specimen surfaces remain completely bare during microscopy and hardness testing. Contamination of equipment is avoided by using disposable plastic stages on microscopes and other apparatus, and by such techniques as enclosing specimens in rubber hydrochloride films for x-ray diffractometry. Samples requiring heat treatment are sealed in evacuated glass or silica capsules and are loaded into hooded furnaces. The air sampling and general contamination control programs are discussed. (auth)

14811 A/CONF.15/P/529
Los Alamos Scientific Lab., N. Mex.
PYROMETALLURGICAL PURIFICATION OF PLUTONIUM REACTOR FUELS. J. A. Leary, R. Benz, D. F. Bowersox, C. W. Bjorklund, K. W. R. Johnson, W. J. Maraman, L. J. Mullins, and J. G. Reavis. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Pyrometallurgical methods studied are liquation, self-drossing and filtration, slagging by the addition of oxide, carbide, or halide, liquid metal extraction, complete conversion to halide, followed by filtration and selective reduction of the plutonium, and electrorefining. Experimental techniques and results are presented for each method. (auth)

14812 A/CONF.15/P/538
Argonne National Lab., Lemont, Ill.
DEVELOPMENTS IN MELT REFINING OF REACTOR FUELS. L. Burris, N. R. Chellew, S. Lawroski, G. A. Bennett, A. A. Chilenskas, M. Ader, H. M. Feder, J. B. Knighton, I. O. Winsch, J. Wolkoff, and W. A. Rodger. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

After investigation of various oxides, zirconia were selected as the crucible material. Data are presented on cerium removal rates from up to 5 kg of material, determined as a function of temperature. Studies were also made on the possibility of effecting separation of zirconium as a carbide or nitride. Separation of purified metal is effected by top pouring. On a 2 to 5 kg scale purified ingot yields were slightly greater than 95% using charges of small reactor fuel pins. Methods are discussed for handling fission product gases and volatilized metals including sodium which may accompany the fuel pin charges and the volatile fission product metals such as cesium. A brief description is given of the auxiliary process under development for processing crucible residues and material deliberately removed to provide the necessary periodic removal of noble elements. A description of the equipment and tests of various materials of fabrication are discussed. The results of preliminary experiments to ascertain the behavior of plutonium are also described. (auth)

14813 A/CONF.15/P/539
Argonne National Lab., Lemont, Ill.
RECENT DEVELOPMENTS IN FLUORIDE VOLATILITY PROCESSING OF REACTOR FUELS. R. K. Steunenberg, J. Fischer, S. Vogler, M. J. Steindler, M. Adams, G. Goring, R. C. Vogel, W. A. Rodger, W. J. Mecham, and W. B. Seefeldt. 32p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Development work on the processing of fuel alloys containing enriched uranium and zirconium is reported. The alloy is dissolved at a temperature of 600°C in an approximately equimolar melt of sodium fluoride and zirconium fluoride, which is sparged with hydrogen fluoride vapor. The resulting tetrafluorides of zirconium and uranium dissolve in the melt as they are formed. The uranium is volatilized as the hexafluoride by sparging the melt with fluorine or bromine pentafluoride vapor. Data on the dissolution rates and the uranium volatilization have been obtained in both laboratory and semi-works investigations. Equipment problems are discussed and a design as well as initial operating experience is presented of a semi-works scale dissolver-hydrofluorinator of all graphite construction. Corrosion data on metal and graphite under dissolution conditions are reported. Included are recent studies relating to fission product behavior in fluoride systems, the corrosion rates of certain metals in fluorine at elevated temperatures, and the handling of plutonium hexafluoride in the vapor phase. (auth)

14814 A/CONF.15/P/540
Argonne National Lab., Lemont, Ill. and Brookhaven National Lab., Upton, N. Y.
PURIFICATION OF REACTOR FUELS AND BLANKETS BY CRYSTALLIZATION FROM LIQUID METAL SOLVENTS. Harold M. Feder and Robert J. Teitel. 37p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A review of investigations of reactor fuels and blanket reprocessing methods which have common features is presented. These methods include dissolution of the irradiated material in a low-melting liquid metal, with separation by selective oxidation and reduction, and cooling to form intermetallic compounds of thorium, uranium, or plutonium with the solvent metal. During crystallization, separations may take place because of favorable solubility relations or co-precipitation, with final separation by filtration, centrifugation, or decantation, and subsequent volatilization or leaching to recover the desired material. The specific recovery processes are discussed, and possible areas of future applications are pointed out, along with a discussion of unsolved problems. (J.R.D.)

14815 A/CONF.15/P/545
Grand Junction Operations Office, AEC.
THE ROLE OF PROCESS DEVELOPMENT IN WESTERN UNITED STATES URANIUM PROCUREMENT. J. W. Barnes. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Process research and pilot plant operation have accelerated the expansion of uranium concentrate production in the Colorado Plateau region, and have reduced the cost of this production. Reduction of costs has permitted treatment of ores previously considered too low grade or refractory, adding many millions of tons to available economic ore reserves. A table is shown, comparing average grade, recovery, costs, production, and ore reserves for several years. The timing of adoption of significant process improvements is related, and the advantages of these changes are discussed. Each mill made changes at various times, when improved processes became sufficiently proven, and reasons are given for adoption of one or another alternative process. Tables show the situation at yearly intervals for the last several years. The trend is toward an increasing number of solvent extraction and carbonate plants. Plants covered in this way include all those now contracted. Growth trends are shown since 1955, together with figures on consumption of major supply items, employment, and usage of fuel and electrical energy, to illustrate the size of the industry. An attached table traces certain process developments and timing from fundamental research to pilot plant to full scale plants. (auth)

14816 A/CONF.15/P/622
Atomic Power Development Associates, Inc., Detroit and Battelle Memorial Inst., Columbus, Ohio.
RADIATION STABILITY OF FUEL ELEMENTS FOR THE ENRICO FERMI POWER REACTOR. D. O. Leeser, F. A. Rough, and A. A. Bauer. 12p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The irradiation test program on fuel elements for the Enrico Fermi Reactor has covered binary alloys of U–Cr, U–Zr, and U–Mo. The U–5 wt. % Cr eutectic alloy investigation showed insufficient radiation stability for use in a fast reactor being developed as a possible commercially practicable means of producing electric power. Preliminary studies on U–Zr alloys containing 2, 2.2, 3, 5, 10, and 15% by weight of Zr and U–Mo alloys containing $3\frac{1}{2}$, 5, 7, and 10% by weight of Mo have been performed. Various heat treatments were used in preparing the alloyed specimens to determine which treatment, if any, would result in improved radiation stability. A screening program on these binary alloys at low burn-ups (about 0.1 total at. %) indicated that the U–10 wt. % Mo alloy possessed the best stability of the alloys studied, and provided a good reduction of the anisotropic behavior of fabricated U. Therefore, this material was selected as the reference fuel alloy for the Enrico Fermi Reactor. Test data reported include that performed on specimens that were bare, Zr clad with open ends, and Zr clad with ends capped with Zr and with stainless steel. In general, it can be stated that (a) the radiation stability

of the gamma treated 10 wt. % material below 1100°F is good to 2 at. % burn-up, (b) large changes that occurred, such as swelling or ruptures, have occurred at burn-up less than 1.5 at. % in material irradiated above 1300°F, and (c) ruptures occurred in material that is restrained by heavy cladding (8 mil or greater) and/or material that is fabricated improperly. These latter criteria are detailed as to the effects of each and their relative importance to radiation stability. (auth)

14817 A/CONF.15/P/696
Bureau of Mines, Albany, Oreg.
GADOLINIUM AND EUROPIUM ALLOYS—THEIR PREPARATION, MELTING AND PROPERTIES. M. L. Wright, F. E. Block, and H. Kato. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The investigation included the preparation of rare earth metals, the preparation of alloys involving rare earth elements, and the evaluation of the alloys by chemical analyses and physical tests. By preparing rare earth metals from their fluoride salts rather than from the chloride salts, the oxygen content was reduced from a value within the range of 1000 to 1500 ppm to a value within the range of 200 to 400 ppm. All gadolinium used in this investigation was made from the fluoride by reduction with calcium. Elemental europium was prepared by reducing the oxide with lanthanum in vacuum. The resulting metal contained 98 to 99% europium with impurities of calcium 0.1 to 1%, carbon 470 to 500 ppm and nitrogen 40 to 150 ppm. Homogeneous gadolinium–titanium and gadolinium–stainless steel alloys containing up to 20% gadolinium were successfully made in small melts by arc-melting in an inert atmosphere. Hardness and brittleness of nickel, Inconel, and stainless steel were found to increase with increasing gadolinium content, however, titanium–gadolinium alloys were found to be ductile. Stainless steel or titanium alloys with 0.2 to 0.5% europium could be cold-rolled from the as-cast condition through reductions of 93 to 96%. Both titanium and stainless steel alloys containing up to 25% gadolinium were found to be resistant to the corrosive action of pressurized hot water and steam; similar zirconium base alloys were found to be non-resistant. (auth)

14818 A/CONF.15/P/698
Bureau of Mines. Electrometallurgical Experiment Station, Boulder City, Nev.
ELECTROREFINING OF VANADIUM, CHROMIUM, ZIRCONIUM, AND HAFNIUM. D. D. Blue and D. H. Baker, Jr. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The inert-gas-shielded, molten-salt, electrorefining technique has proved adaptable to improving the quality of a number of metals, in addition to those discussed. The basic method is very promising for refining a number of metals that have resisted purification by established techniques. The selection of electrolytes and operating variables has to date been arbitrary and empirical, in many instances. The theory and chemistry of the process are as yet vague and little understood. Although there is nothing inherently expensive in the electrorefining procedure, mechanical improvements will undoubtedly permit easier operation and less drastic controls. The method offers a challenging field of research for developing sampling and analytical techniques, evolving chemistry to permit theoretical selection of promising and workable electrolytes, and devising of mechanical innovations permitting continuous, less exacting operation. (auth)

14819 A/CONF.15/P/706
Atomics International Div., North American Aviation Inc., Canoga Park, Calif.
STUDY OF THE THORIUM–URANIUM ALLOY SYSTEM. G. G. Bentle. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The thorium–uranium phase diagram has been determined from 0 to 20 wt. % uranium. A new high-temperature region in the phase diagram is proposed. The data were obtained from resistivity and lattice parameter measurements. Metallography indicates that uranium has a slight solubility in thorium, that is, about 1% at room temperature. The excess uranium occurs as a finely divided second phase in arc-melted alloys. The fine particles coalesce when the alloys are held at 600°C for several months, a thermal treatment which might be encountered in the operation of a nuclear power reactor. Mechanical property measurements indicate that thorium is strengthened at room temperature and at 500°C by adding uranium; three or four percent uranium added to thorium increases the strength of thorium about 50% at the respective temperatures. The thermal conductivity for several alloys was calculated as a function of temperature, using resistivity data and the Weidemann-Franz relation. The thermal conductivity of thorium was found to increase approximately linearly from 0.090 at 100°C to 0.110 cal/cm/°C/sec at 1100°C. (auth)

14820 A/CONF.15/P/707
Martin Co., Baltimore.
IRON–ALUMINUM BASE ALLOYS FOR REACTOR COMPONENTS. William A. Maxwell, Blake King, J. Mueller, and N. Ida. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Each of the materials presently available for cladding fuel elements and other power reactor core components is shown to represent a poor compromise as far as nuclear, physical, chemical, and cost characteristics are concerned. Alloys based on the iron–aluminum system are noted to be cheap, extremely corrosion-resistant, and to have only a moderate neutron-capture cross section. Their usefulness as canning materials is described as having been greatly limited, however, by their brittleness and poor high-temperature strength. The procedure followed by the authors in a current program aimed at developing families of ductile Fe–Al base alloys for use in water-cooled, liquid-metal cooled, and gas-cooled reactors is described. The metallurgical peculiarities of iron–aluminum alloys are discussed, and the reasoning followed in selecting desirable alloying additions is outlined. The importance of close integration of alloy preparation, fabrication methods development, and testing activities is emphasized. Properties of promising interim alloys are compared with corresponding properties of currently available materials, and are discussed in relation to the economics of reactor construction and operation. Their peculiar combination of corrosion resistance and ease of reprocessing is pointed out as a major advantage of iron–aluminum base alloys. Special emphasis is given to an evaluation of the effects of nuclear bombardment on the structure of these alloys. It is concluded that the required ductility and high-temperature strength can be imparted to iron–aluminum base alloys, and that they are likely to become competitive with stainless steels, zirconium alloys, and other materials on the basis of over-all fuel-cycle costs. (auth)

14821 A/CONF.15/P/709
Westinghouse Electric Corp. Bettis Plant, Pittsburgh.
THE THERMAL DIFFUSION OF HYDROGEN IN ZIRCALOY-2. J. M. Markowitz. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The thermal diffusion of hydrogen in Zircaloy-2 was studied at a series of temperature gradients for initial concentrations of hydrogen such that both single-phase alpha and two-phase alpha plus delta regions were included. Both the extent of redistribution as a function of time and the properties of the concentration distribution at the ultimate steady state were studied. From the latter data, the heat of transport, Q*, was determined and used to calculate steady state concentration gradients in Zircaloy-2 under conditions conforming to reactor operations. The kinetic data were used for estimating the time required to reach steady state from various initial conditions. An atomic mechanism for thermal diffusion of hydrogen in zirconium is suggested. (auth)

14822 A/CONF.15/P/712
Battelle Memorial Inst., Columbus, Ohio.
EFFECTS OF ALLOYING ON THE KINETICS OF OXIDATION OF NIOBIUM. W. D. Klopp, C. T. Sims, and R. I. Jaffee. 39p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Kinetics of the air oxidation of pure niobium and of niobium binary alloys containing up to 25 at. % vanadium, 10 at. % molybdenum, 24 at. % chromium, 10 at. % tungsten, 35 at. % titanium, and 45 at. % zirconium have been studied at elevated temperatures. Results of these studies have suggested several principles for the oxidation of niobium: (a) ionic diffusion is rate-controlling under certain conditions when apparent linear oxidation is observed, and (b) alloying elements can effect the oxidation behavior by expanding or contracting the partially protective Nb_2O_5 scale, by valence effects on diffusion rates through the scale, and by formation of new scales. Pure niobium oxidizes linearly at 600 to 1200°C. Moisture increased the oxidation rate at 600°C. The scales consisted of an inner, adherent, oriented layer of Nb_2O_5, containing traces of NbO, and an outer, porous layer of Nb_2O_5. The oxide initially forms as adherent, protective Nb_2O_5, but high compressive stresses developed as a result of the high oxide/metal volume ratio (2.69) cause the scale to crumble at a relatively low thickness. A steady state reaction ensures, with oxidation following the linear time law. On the basis of preliminary experiments it is believed that ionic diffusion, probably of oxygen ions, through the inner layer is the rate-controlling reaction. Alloying can affect oxidation behavior by three mechanisms: (1) Alloying additions with smaller crystal radii than that of niobium contract the Nb_2O_5, promoting protective scales and parabolic oxidation, while larger ions expand the scale and increase the linear oxidation rates. (2) Valence of the alloying addition has a relatively minor effect on diffusion rates through the scale because of the large number of defects in Nb_2O_5. (3) At alloying levels beyond the solubility limit of Nb_2O_5 for the alloying ion, the oxidation rates are determined by the properties of new scales. (auth)

14823 A/CONF.15/P/713
Argonne National Lab., Lemont, Ill.
ADVANCES IN THE PHYSICAL METALLURGY OF URANIUM AND ITS ALLOYS. H. H. Chiswik, A. E. Dwight, L. T. Lloyd, M. V. Nevitt, and S. T. Zegler. 35p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A general survey is presented of information in the uranium alloy field. Emphasis is centered on alpha uranium-rich alloys of special interest as uranium-base fuel element materials. The systems treated include uranium-molybdenum, uranium-silicon, uranium-zirconium, uranium-niobium, and uranium-zirconium-niobium (high uranium compositions). The uranium-fissium alloys are discussed in relation to their projected applications as fast reactor fuels. Equilibrium diagrams, transformation kinetics, and other pertinent data are presented for the uranium plus "fissium" element systems, e.g., uranium-ruthenium, uranium-rhodium, uranium-palladium, and uranium-molybdenum-ruthenium. The properties covered include constitution phase diagrams, metallographic structure, physical and mechanical properties, transformation kinetics, crystallographic structure, thermal cycling, and irradiation stability (where pertinent). Correlations between microstructure, heat treatment, and dimensional stability are emphasized, with particular reference to the U-2 wt. % Zr, U-5 wt. % Zr, and 1½ wt. % Nb alloys. A discussion of the role of alloying and heat-treatment in improving the dimensional stability and corrosion resistance of uranium is presented, and an evaluation is made of the present status in attaining these objectives. (auth)

14824 A/CONF.15/P/784
Martin Co., Baltimore.
A NEW FABRICATION TECHNIQUE FOR THE PRODUCTION OF STAINLESS STEEL OXIDE DISPERSION FUEL ELEMENTS. S. Shapiro. 13p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The adaption of a new fabrication method in the production of a thin walled stainless steel oxide dispersion fuel element is presented. The fuel section of this element is 23 ± ⅜ in. in length with a thickness of 0.0175 to 0.0185 in. and an inner and outer clad of 0.005 to 0.006 in. in thickness. The major points of interest in this fabrication technique are as follows: application of high fired UO_2 and the manner in which fuel and burnable poison loading is controlled, powder rolling of a stainless steel–UO_2 cermet and further processing to give it sufficient ductility to permit forming around a small radii, development of a technique for chemically cleaning the cermet core tube and its inner and outer clads so that reproducible bonds could be had in production, and the adaptation of recrystallization bonding by the production circuit in such a manner that no macroscopic discontinuities were observed and less than 5% of the elements had any microscopic discontinuities. A successful core loading of this type fuel element has been completed. This factor taken into consideration with compiled production data indicate that the product is well suited for economical reactor core loadings of the tubular type fuel elements. (auth)

14825 A/CONF.15/P/788
Battelle Memorial Inst., Columbus, Ohio.
PREPARATION OF REACTOR COMPONENTS BY A GAS-PRESSURE BONDING TECHNIQUE. S. J. Paprocki, E. S. Hodge, and C. B. Boyer. 41p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A new method for cladding fuel elements and fabricating subassemblies and other reactor components, gas-

pressure bonding, was studied. Some results with Zr and Zr alloys are given. Work was done on the cladding of various materials with stainless steel, Mo, Nb, and Ti. Such materials as Ti–B dispersions and UO_2 were clad using this technique. (M.H.R.)

14826 A/CONF.15/P/789

General Atomic Div., General Dynamics Corp., San Diego, Calif.

THE PREPARATION AND PROPERTIES OF ZIRCONIUM–URANIUM–HYDROGEN ALLOYS. U. Merten, L. J. Dijkstra, F. D. Carpenter, A. P. Hatcher, and L. D. Le Grange. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Zirconium hydride was chosen as the moderator for a group of solid homogeneous reactors currently on the market. The fuel material for these reactors is prepared by first making a zirconium-enriched uranium alloy by conventional melting techniques and then adding hydrogen at elevated temperature in a gas-handling system. All necessary forming operations are performed on the zirconium–uranium alloy before the hydrogen is added, so that the relatively brittle final alloy is ready for cladding without further handling. Zirconium–hydrogen and zirconium–uranium–hydrogen alloys containing up to 1.9 hydrogen atoms per zirconium atom have been prepared by this direct hydriding technique. The hydriding conditions must be somewhat carefully controlled if cracking or disintegration of the material during hydriding is to be avoided. The physical disruption which often accompanies such a process can be understood in terms of the phase changes which occur during the hydriding. Thus, at the temperatures employed, approximately one mole of hydrogen can be added per mole of zirconium before the solubility of hydrogen in beta zirconium is exceeded. Further hydrogen additions cause precipitation of a brittle hydride phase, with the result that proper control of this portion of the procedure is particularly important. An investigation of a portion of the zirconium–uranium–hydrogen phase diagram has been made to help determine the optimum conditions for preparing the ternary alloy. This investigation was carried out, in part, by an unusual dilatometric technique in which one alloy component, hydrogen, was added isothermally in the dilatometer. This technique gave directly the most useful quantities, the density changes which occurred on hydriding. Measurements of physical properties and observation of gross radiation effects have shown the ternary alloy to be suitable for the low-power use intended, and have begun to define the general operating conditions under which the material is useful. (auth)

14827 A/CONF.15/P/803

General Atomic Div., General Dynamics Corp., San Diego, Calif.

ADVANCES IN THE APPLICATION OF RADIOISOTOPES AND NUCLEAR IRRADIATION IN METALLURGICAL RESEARCH, M. T. Simnad. 21p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A wide range of topics is covered since radioisotopes have found application in almost all branches of metal research, namely, in studies of segregation, friction, vapor pressure, slag-metal reactions, electrolytic action and corrosion on metal surfaces, and diffusion and oxidation. A description is given of recent unpublished work on heterogeneous nucleation of metals from the vapor phase. Radioisotopes have provided a unique means for studying the metal condensation process from atomic beams on various substrates. (auth)

14828 A/CONF.15/P/1010

Westinghouse Electric Corp. Bettis Plant, Pittsburgh.

THE MELTING AND FABRICATION OF ZIRCALOY. E. L. Richards, J. H. Hart, W. H. Friske, and W. J. Hurford. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A survey of the evolution of double, consumable-electrode, arc-melting techniques for zirconium alloy ingots is given. Current melting specifications are presented and the reasons for specifying those conditions are discussed. The effects of varying the furnace pressure and the level of sponge volatiles are discussed. Ingot grain size, volatile impurity content, and porosity are related to the melting techniques. Ingot sampling and conditioning techniques are discussed along with the advantages and process control achieved by these methods. Data are presented for the melting rate and power consumption rate with respect to the melting conditions. Techniques for pressure sponge into bars and welding these bars into consumable electrodes are discussed. Machining and welding of first melt ingots into the remelt electrode are described. The controls and techniques used for arc starting and arc voltage control are explained along with the power source and the general furnace design. Vacuum melted Zircaloy-2 is shown to contain fewer microstructural defects than Zircaloy-2 melted under one atmosphere of argon. Zircaloy ingots are hot worked to common mill products by such processes as press forging, hammer forging, blooming, extrusion, and hot rolling. These processes, as applicable to the fabrication of Zircaloy, are discussed and information on hot working and annealing temperatures and conditions, mill reductions and methods for billet and slab conditioning are discussed. Processes for producing cold rolled strip, tubing, wire, and similar products by rolling, extruding, swaging, or drawing techniques are described. The effects of impurities, ingot soundness, and fabrication practice on the quality of wrought products are discussed, and results of macro and microstructural studies of ingot, intermediate shape, and final wrought product are presented. (auth)

14829 A/CONF.15/P/1032

Ames Lab., Ames, Iowa and Iowa State Coll., Ames. Inst. for Atomic Research.

FEASIBILITY STUDIES ON MOLTEN METAL REACTOR COMPONENTS. Ray W. Fisher and Charles B. Fullhart. 17p. (ISC-1020(Rev.)). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Several aspects of the design of a successful molten metal reactor are discussed such as corrosion, mass transfer, heat transfer, pumping rates, electrical characteristics, and fabrication of various metals and alloys which might serve as possible fuels, blankets, or container materials. The electrical resistivity of Ta, Y, Inconel, stainless steel, and various fuels are tabulated. The corrosion rate and mass transfer are described for the following system: Th–Mg eutectic in Ta at 800 to 920°C, 95% Bi–5% U (by weight) in Ta at 950 to 1050°C, and U–Cr eutectic in Y at 900 to 1000°C. (M.H.R.)

14830 A/CONF.15/P/1081

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

THE TENSILE PROPERTIES OF PURE PLUTONIUM

AND SOME ALUMINUM–PLUTONIUM ALLOYS. H. R. Gardner, C. H. Bloomster, and J. M. Jefferes. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

As cast and as cast-delta phase annealed pure plutonium tensile specimens were tested at an average temperature of 31°C. In addition, the room temperature tensile properties of cast aluminum–plutonium alloys from 0 to 13 wt. % plutonium were determined. Ultimate and yield strength, modulus of elasticity, modulus of resilience, elongation, density, and hardness data are presented. (auth)

14831 A/CONF.15/P/1433

Mallinckrodt Chemical Works, St. Louis.

PRODUCTION FORMING OF NATURAL URANIUM METAL. John A. Fellows. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Methods of forming natural uranium metal as applied to various grades of uranium and as practiced in standard feed material production are described. Improved forming techniques of particular promise are also described. (auth)

14832 A/CONF.15/P/1776

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

PLUTONIUM FUELS DEVELOPMENT. O. J. Wick, T. C. Nelson, and M. D. Freshley. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A description of plutonium fuel element development at Hanford including the fabrication of fuel for the Materials Test Reactor at Arco, Idaho, the fabrication of fuel for the Plutonium Recycle Test Reactor at Hanford, plutonium fabrication techniques under development, and irradiation testing of a variety of possible plutonium containing fuels is presented. The irradiation of alloys of aluminum containing up to 10 wt. % plutonium is described. These alloys have been irradiated to high burnouts and the results of these irradiations are presented. Plutonium containing fuel materials such as mixed crystal oxides of PuO_2 and UO_2 have been fabricated and irradiated. Fuel materials which consist of mixtures of PuO_2 and other oxides have been investigated as well as inert materials which have been impregnated with PuO_2. The self-shielded fuel element concept is also being developed. (auth)

14833 A/CONF.15/P/1780

Atomics International Div., North American Aviation Inc., Canoga Park, Calif.

METHODS AND EQUIPMENT FOR LOW DECONTAMINATION PROCESSING OF METALLIC NUCLEAR FUELS. G. E. Brand, D. I. Sinizer, E. W. Murbach, W. N. Hansen, J. R. Foltz, and K. L. Mattern. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Low decontamination reprocessing methods for metallic nuclear fuels are under development. Small scale experiments are currently being conducted with gram quantities of irradiated thorium–uranium alloys. In addition, equipment, methods, and techniques are under development for a prototype multikilogram plant to process high burn-up uranium metal fuel remotely. Several high temperature methods were investigated as possible processes for the decontamination of thorium reactor fuels. Gram quantities of irradiated thorium–uranium alloy were arc-melted between a tungsten electrode and a water-cooled copper hearth in an inert atmosphere. The observed results indicated a 95% removal of cesium and strontium, 70% removal of total rare earths and little or no removal of zirconium and ruthenium. Under extreme conditions excessive amounts of uranium in the Th–U can be evaporated. (auth)

14834 A/CONF.15/P/1781

Brookhaven National Lab., Upton, New York.

REMOVAL OF FISSION PRODUCTS FROM URANIUM–BISMUTH FUELS. O. E. Dwyer, A. M. Eshaya, and F. B. Hill. 24p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Processing of fuel, consisting of U, Mg, and Zr in Bi, for the LMFR is described, and recent experimental results are discussed. The volatile fission products to be removed are Xe and Kr, which are removed by the same methods. Non-volatile fission products include high cross-section rare earths; these can be removed from the fuel by fused chloride melts. Two methods of removal of Zr to minimize corrosion are described. A method is given for removal of fission products whose chlorides are less stable than $BiCl_3$ and those whose chlorides are more stable than $BiCl_3$ but less stable than UCl_3. (J.R.D.)

14835 A/CONF.15/P/1785

Battelle Memorial Inst., Columbus, Ohio and Westinghouse Electric Corp. Bettis Atomic Power Div., Pittsburgh.

PHYSICAL METALLURGY AND PROPERTIES OF ZIRCONIUM–URANIUM ALLOYS. A. A. Bauer, S. Kass, and K. M. Goldman. 23p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The constitution and transformation kinetic behavior of uranium-zirconium alloys are presented. The system is characterized by complete solid solution between gamma uranium and beta zirconium at elevated temperatures and by the intermediate hexagonal epsilon phase which forms from this solution at about 600°C and contains approximately 50 wt. % uranium. Oxygen and nitrogen have a pronounced effect on alloy constitution, stabilizing the alpha-zirconium phase, and restricting the epsilon and beta phase regions. The high-temperature beta phase can be retained in alloys containing 20 to 70 wt. % uranium by quenching, the beta phase decomposing by a nucleation and growth process to epsilon. Physical, mechanical, and corrosion property data are summarized in tabular and graphic form and are related to alloy constitution and transformation kinetic behavior. The irradiation behavior of uranium-zirconium alloys is reviewed. The mechanical strength is found to be dependent not only upon composition but also upon the type, amount, and distribution of phases in the microstructure. The control of microstructure through heat treatment is of primary importance in controlling strength since the decomposition products of the high-temperature beta phase are particularly sensitive to uranium content. The aqueous corrosion behavior is found to be influenced by water temperatures, amount and distribution of phases, oxygen content, and cooling rate from the beta phase region. The irradiation behavior appears to be relatively insensitive to microstructure but is markedly dependent on irradiation temperature. Low volume changes are exhibited by alloys containing up to 80 wt. % uranium when irradiated at low temperatures. Irradiations in excess of 600°C, at beta phase temperatures, are found to produce volume increases as high as 50% per 1 at. % burnup. (auth)

14836 A/CONF.15/P/1990
Oak Ridge National Lab., Tenn.
METALLURGICAL PROBLEMS IN MOLTEN FLUORIDE SYSTEMS. W. D. Manly, J. H. Coobs, J. H. DeVan, D. A. Douglas, H. Inouye, P. Patriarca, T. K. Roche, and J. L. Scott. 30p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The important metallurgical problems relevant to circulating fuel reactors utilizing fused fluoride systems are discussed. The successful utilization of such mixtures is in large measure dependent upon the development of reactor materials which can both contain the mixtures under reactor conditions and afford useful structural properties. Paramount among the materials requirements which must be fulfilled are the following: resistance to corrosion by the fluoride fuel or salt (in the presence of a neutron flux), resistance to oxidation by air, and good elevated-temperature strength. Materials must also be easily formed and welded into relatively complicated shapes and be metallurgically stable over a wide temperature range. The most stringent materials requirement is adequate corrosion resistance to the molten fluorides which are used as fuel carriers. Generally speaking, corrosion problems are solved by either formation of a protective film through action of the corrosive environment or the establishment of thermodynamic equilibrium between the material and corrosive environment before significant corrosion occurs. The first approach has been used quite successfully with metals exposed to gas or high-temperature water but with only limited success with liquid metals and molten salts. For the latter, especially molten fluorides which are excellent fluxing agents, the second approach, i.e., thermodynamic equilibrium, is preferred. (auth)

14837 A/CONF.15/P/1993
Oak Ridge National Lab., Tenn.
RECENT ADVANCES IN THE METALLURGY OF ZIRCONIUM AND TITANIUM ALLOYS OF SPECIAL INTEREST IN REACTOR TECHNOLOGY. G. M. Adamson, Jr., J. O. Betterton, Jr., J. H. Frye, Jr., and M. L. Picklesimer. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Zirconium alloys are presently available with better neutron and corrosion properties than any other known reactor material of comparable strength and ductility. Progress has been made towards resolving some of the special problems in these and certain titanium alloys such as fabrication and welding procedures, improved corrosion resistance under heavy particle bombardment, and the delineation of burning hazards. Ultimately, alloy development may permit full utilization of the strong binding forces in these metals, indicated by their high melting point and heat of vaporization, in terms of mechanical strength at higher temperatures. More immediately, alloys which are less sensitive and more resistant to contamination in fabrication are urgently required to reduce the cost of preparing zirconium and titanium materials. (auth)

Tracer Applications

14838 A/CONF.15/P/834
Illinois. Univ., Urbana.
TRACER STUDIES OF INTERMETALLIC DIFFUSION. David Lazarus. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The availability of radioactive tracers of high purity and high specific activity has provided the possibility of determining diffusion coefficients with extreme accuracy. Using relatively simple techniques, it is now possible to determine diffusion coefficients in many common materials to an accuracy of about 1%. By determining the diffusivity of various tracers at several different temperatures, activation energies for the diffusion process can be determined to a precision of a few tenths of 1%. The results of such precise measurements have been of considerable value in elucidating the fundamental mechanism responsible for diffusion in various impurities in a pure metal, compared with the rate of self-diffusion, have provided quantitative rules for predicting a number of other important properties of various alloys of the base metal, such as thermal and elastic behavior. (auth)

PHYSICS

14839 A/CONF.15/P/695
Michigan State Univ., East Lansing.
BULK PROPERTIES OF STABLE ISOTOPES AS A PROBE FOR LIQUID-STATE AND SOLID-STATE INVESTIGATIONS. D. J. Montgomery. 8p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The availability of certain isotopes in bulk has made possible some new studies in solid- and liquid-state physics. Initial studies on lithium are described, the differences in lattice constant, bulk density, electric resistivity, thermoelectric force, and melting point for Li^6, Li^7, and natural Li being compared. (T.R.H.)

14840 A/CONF.15/P/809
Army Medical Research Lab., Fort Knox, Ky.
OPTIMUM X-RAY YIELDS IN BETA-EXCITED X-RAY SOURCES. J. G. Kereiakes and A. T. Krebs. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A conference version of AMRL-349.

The experimental setup was so arranged that various thicknesses of target material could be studied with and without effect of backing material. The x radiations were detected by a NaI(Tl) crystal ($1\frac{1}{2}$ in. diameter by 1 in. thick and having a 3 mil Al window to increase low-energy counting efficiency) coupled to a DuMont 6292 photomultiplier tube. The photomultiplier pulses were amplified and analyzed with a single-channel pulse-height analyzer. Optimum K x-ray yields were determined by placing various thicknesses of target foils between isotope (evaporated on Mylar films) and detector. Sn target foil thicknesses of about 55, 80, and 80 mg/cm^2 gave optimum K x-ray yields for Tl^{204} (0.765 Mev), P^{32} (1.701 Mev), and Sr^{90}–Y^{90} (2.18 Mev), respectively, with no backing material. Ta target foil thicknesses of about 200 and 220 mg/cm^2 gave optimum K x-ray yields for P^{32} and Sr^{90}–Y^{90}, respectively. Optimum K x-ray yields found for Pb target foil thicknesses were 275 and 300 mg/cm^2 for P^{32} and Sr^{90}–Y^{90}, respectively. In all cases, the optimum K x-ray yields were increased two-fold by the addition of foil backing material of same thickness as that providing optimum K x-ray yields. Increase of foil backing material to a thickness that absorbed all betas further increased optimum K x-ray yield by about 12 to 18%. The findings show definitely that proper source configuration can greatly increase

the efficiency of beta-excited x-ray sources and thus their possible use in the energy region where no suitable gamma-emitting isotopes presently exist. Their stability, economy, portability, and independence of power requirements are added advantages of these sources. Moreover, by source fabrication to allow interchanging of target materials and B-emitting isotopes, x-ray sources capable of giving various relatively monoenergetic x-ray energies are possible, in contrast to fixed gamma energies emitted by presently available isotopes. (auth)

14841 A/CONF.15/P/1018
Argonne National Lab., Lemont, Ill.
OPERATION AND ACTIVITIES OF THE REACTOR PHYSICS CONSTANTS CENTER. B. I. Spinrad and R. Avery. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Reactor Physics Constants Center was organized in the spring of 1956 to formalize and correlate the integral data used for reactor physics and reactor design calculations. An initial compendium of data was published in early 1958 for review and criticism. A revised and improved edition is planned, contingent on the number of corrections and additions received. (W.D.M.)

14842 A/CONF.15/P/1544
General Electric Co. Electronics Lab., Syracuse, N. Y.
ELECTRICAL CHARACTERISTICS OF HIGH DENSITY, HIGH PURITY TITANATE CERAMICS. D. A. Lupfer. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The development of a dielectric system to be used in capacitors for the storage and discharge of electrical energy is reported. The objectives for the finished system were to store large amounts of energy per unit volume, and to release at least 75% of the energy in very short time intervals. The work is incomplete, but the dielectric material development has proceeded far enough to demonstrate a good measure of success. A nonpiezoelectric $(Ba,Sr)TiO_3$ ceramic composition was chosen for study, as some electrical properties were well known, high purity materials were available, and the preparation techniques were well established. The techniques chosen for achieving high dielectric strength were to relieve electrical stresses in the samples, eliminate macroscopic flaws, and increase the density as high as possible. The material development proceeded by the development of fine powder pressing techniques, calcination methods, and the final sintering operation. This last was optimized by control of the time-temperature-atmosphere reaction variables. The samples were prepared for electrical testing by grinding contours into the ceramic discs which relieved edge stresses and provided a central flat area for study. Then electrodes were sputtered onto the surfaces, and electrical tests performed. The results show that densities of the samples were increased to 98.7% of theoretical. Visible flaws were eliminated, and a partial translucency was gained. The samples displayed an increasing dielectric constant with increasing density. Low losses were obtained. The dielectric constant decreased with increasing electric field, so the capacitor behavior is nonlinear. Energy storage values of 0.5 joules/cm^3 appear practical at present, and it may eventually be possible to obtain values as high as 1 joule/cm^3. (auth)

Astrophysics

14843 A/CONF.15/P/353
California Inst. of Tech., Pasadena. W. K. Kellogg Lab. of Radiation.
TEMPERATURE AND DENSITY CONDITIONS FOR NUCLEOGENESIS BY FUSION PROCESSES IN STARS. William A. Fowler. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An attempt is made to correlate nuclear findings with what is known about stellar evolution. Some discussion is given to present research in nuclear physics and astrophysics which may lead to further elucidation of the problem of nucleogenesis and of its cosmological implications. (M.H.R.)

Crystallography and Crystal Structure

14844 A/CONF.15/P/1764
Brookhaven National Lab., Upton, New York.
NEUTRON DIFFRACTION STUDIES OF MAGNETIC STRUCTURE. J. M. Hastings, N. Elliott, L. M. Corliss, and W. C. Hamilton. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Antiferromagnetism in inorganic compounds is thought to result from exchange interactions between magnetic ions operating through nonmagnetic connecting ions. The antiferromagnetic structures of Fe_3O_4, MnS_2, $MnSe_2$, MnS, and $MnTe_2$ were obtained by neutron diffraction in order to test the validity of this idea and to explore further the dependence of magnetic structure on crystal structure. (W.D.M.)

Electrical Discharge

14845 A/CONF.15/P/344
Oak Ridge National Lab., Tenn.
THE OAK RIDGE THERMONUCLEAR EXPERIMENT. C. F. Barnett, P. R. Bell, J. S. Luce, E. D. Shipley, and A. Simon. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The DCX is a device designed to grow a hot plasma by trapping energetic particles in a magnetic field. This injection and trapping has already been accomplished and work is under way which should lead to development of the plasma. Experimental results, including details of the trapping mechanism are discussed. Theoretical discussion includes the expected final characteristics of the device, as well as a description of intermediate stages in the formation of the plasma. (auth)

14846 A/CONF.15/P/345
Naval Research Lab., Washington, D. C.
MAGNETIC COMPRESSION OF SHOCK PREHEATED DEUTERIUM. A. C. Kolb. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

It was demonstrated that high velocity shock waves with ion energies greater than 100 ev/ion can be produced by the magnetic acceleration of a deuterium plasma. The plasma is then channeled and compressed by means of pulsed magnetic fields along the axis of the shock tube. Experimental results for ambient pressures from 0.1 to 1.0 mm Hg and magnetic fields of

15,000 to 700,000 gauss are reported. The time scale of these experiments is from 2 to 20 microseconds with peak currents of the order 8×10^6 amperes. Optical observations of the compression, stability, and shock velocity are discussed together with spectroscopic observations of the emitted radiation. (auth)

14847 A/CONF.15/P/347

General Atomic Div., General Dynamics Corp., San Diego, Calif.

THEORY OF PINCH EFFECT—STABILITY AND HEATING. M. N. Rosenbluth. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Some surface instabilities which may arise in the stabilized pinch are discussed. The disassembly and heating of the plasma which results from collision are covered. (M.H.R.)

14848 A/CONF.15/P/348

General Atomic Div., General Dynamics Corp., San Diego, Calif.

FREE HYDROGEN ATOM COLLISION CROSS SECTIONS OF INTEREST IN CONTROLLED THERMONUCLEAR RESEARCH. W. L. Fite. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In order to better understand the processes in establishment of a plasma, especially those processes occurring after the discharge has reached the stage where the deuterium gas is highly dissociated, several reactions involving charged particles and the free hydrogen atom were studied. The hydrogen atoms are produced by thermal dissociation and formed into a neutral particle beam, an arbitrary fraction of which is hydrogen atoms, up to an almost pure atomic beam. The basic signal-to-noise problem is overcome by modulating the neutral beam mechanically; then the signal arising from the interactions involving the atoms in the beam can be identified by its a-c characteristics, i.e., its frequency and phase. In this manner signal-to-noise ratio is made quite satisfactory. Three measurements on hydrogen atom-electron reactions were made to date. In measuring the total ionization cross section the signal used was the positive ion current, after mass analysis. In determining the total cross section for excitation of Lyman alpha radiation (1216 A), the signal used was the photon signal as detected in an iodine-vapor-filled UV photon counter. The scattered electrons constituted the signal when elastic scattering below 10.15 ev was under study, and when total scattering above this electron energy was examined. The measured cross sections for these types of reactions are presented and the relation of these measurements to scattering theory are briefly discussed, especially as regards Born approximation calculations. (auth)

14849 A/CONF.15/P/349

General Atomic Div., General Dynamics Corp., San Diego, Calif. and Texas Atomic Energy Research Foundation, Dallas.

THEORETICAL STRUCTURE OF PLASMA EQUATIONS. M. N. Rosenbluth and N. Rostoker. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A new method is developed for the solution of the linearized transport equation which gives the perturbed distribution function in terms of the perturbed field variables. By facilitating direct use of the properties of particle orbits, a considerable simplification is achieved. In particular, a variational expression is derived for determining stability which is rigorous in the limit of small Larmor radius. (M.H.R.)

14850 A/CONF.15/P/350

Argonne National Lab., Lemont, Ill.

RADIO FREQUENCY THERMONUCLEAR MACHINES. J. W. Butler, A. J. Hatch, and A. J. Ulrich. 17p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The use of radio frequency electromagnetic fields promises additional flexibility in the design of possible thermonuclear reactors, due essentially to the existence of vacuum fields with non-zero curl. Also, it may be that the well known instability of a simply connected plasma body surrounded by a magnetic field can be effectively suppressed by a dynamical stabilizing effect of the periodic field. If, in addition, there should exist a favorable mechanism for transferring the energy of the high energy reaction products to the field, such a general scheme would indeed be attractive. Operating parameters and power balance relationships have been studied for a family of machines designed according to the above principles. In general, it is found that rather large amounts of joule heat must be generated in the metal wall in order to develop sufficient confining pressure at the plasma surface. Of perhaps more importance is the question of the stability of such plasma-field configurations, and a detailed description was prepared of a model experiment designed to test this crucial point. The apparatus will generate and utilize millisecond pulses of r-f energy at a power level of one to ten Mw; conditions which are easily attainable by present engineering methods. The question of energy exchange between reaction products and the field is being studied theoretically, as are other general features of plasma interaction with radio-frequency fields. The latest results of these studies are incorporated. (auth)

14851 A/CONF.15/P/351

Argonne National Lab., Lemont, Ill.

PLASMA STUDIES IN A LOW PRESSURE HIGH FREQUENCY DISCHARGE. A. J. Hatch. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A basic experimental study of high frequency containment and heating phenomena pertinent to thermonuclear processes was undertaken at Argonne National Laboratory. The multipacting mechanism of low pressure high frequency discharge is utilized as a plasma source. The experimental apparatus described incorporates a CW 1 kw 3-50 Mc r-f generator. A demountable double-ended glass bell jar, 30 cm diameter by 45 cm long, contains a pair of 25 cm diameter plane parallel metal electrodes with separation adjustable up to 30 cm. Pressures used are in the range of 10^{-1} to 10^{-5} mm Hg. The relatively large plasma volume reduces the problem of plasma disturbance by the probes. Among the plasma features being studied are the following: characteristics of a 3-dimensional potential well for ions due to excess negative space charge produced by the multipacting mechanism; characteristics of r-f excited plasmoids believed to be the result of large scale longitudinal plasma oscillations; and penetration of the plasma and plasmoids by r-f fields in the presence of static transverse magnetic fields. Methods of investigating these plasma features and preliminary experimental results are discussed. (auth)

14852 A/CONF.15/P/352

General Atomic Div., General Dynamics Corp., San Diego, Calif. and Texas Atomic Energy Research Foundation, Dallas.

EXPERIMENTAL PINCH STABILIZATION WITH LARGE AXIAL MAGNETIC FIELD. D. F. Brower,

R. E. Dunaway, J. H. Malmberg, C. L. Oxley, M. Stearns, D. W. Kerst, F. R. Scott, S. P. Cunningham, and R. G. Tuckfield, Jr. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A solution of the stabilization problem in discharges in gases is one of the primary purposes of experimental work in controlled thermonuclear reactions at this time. The employment of an axial magnetic field contained within the pinching plasma is a means of providing tension in the pinch discharge to counteract the negative tension of the orthogonal magnetic field produced by the pinching current itself. Experimental equipment was made to produce very high axial magnetic fields of 40,000 gauss so that correspondingly large pinch currents can be employed. An important matter to consider and to test experimentally is the influence of the axial magnetic field not trapped within the pinch discharge. Control of the magnitude and direction of this exterior magnetic field was attempted and the influence of its magnitude and direction on stability was studied. Results of experiments are reported. (auth)

14853 A/CONF.15/P/354
Los Alamos Scientific Lab., N. Mex.
STABILITY OF A LINEAR PINCH. Bergen R. Suydam. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A variation principle, developed by I. B. Bernstein, E. A. Frieman, M. D. Kruskal, and R. M. Kulsrud for hydromagnetic stability problems, was applied to the study of a linear, axi-symmetric pinch. It is shown by physical reasoning that a certain class of modes is particularly likely to be unstable, and the class of modes thus singled out is then studied with the aid of the Euler-Lagrange equation of the variation principle. Thus, subject to certain explicitly stated restrictions, conditions necessary and sufficient for stability are deduced. (auth)

14854 A/CONF.15/P/355
Los Alamos Scientific Lab., N. Mex.
ACCELERATION OF PLASMA INTO VACUUM. John Marshall. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The magnetic acceleration of plasma is discussed, and some experiments which have been performed are described. (D.E.B.)

14855 A/CONF.15/P/356
Los Alamos Scientific Lab., N. Mex.
NEUTRONS FROM PLASMA COMPRESSED BY AN AXIAL MAGNETIC FIELD (SCYLLA). W. C. Elmore, E. M. Little, and W. E. Quinn. 6p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The properties of gaseous deuterium under the influence of a rapidly increasing axial magnetic field were studied. Such fields are used to ionize, shock heat, and adiabatically compress the gas, whose initial pressure may be in the range from a few to several hundred microns of mercury. The induced electric field associated with the increasing magnetic field quickly ionizes the gas and the magnetic pressure on the resultant plasma produces an energetic shock wave. Two such shock waves are arranged to collide in a region of a rapidly increasing axial magnetic field, with a more intense field at each end of the region to provide partial containment of the plasma. The latter field, which has a time of rise comparable with the thermalizing time of the deuterium ions, produces a radial compression, and increases the effective plasma temperature. Under suitable conditions a considerable yield of neutrons is noted in the time interval encompassing the instant of peak magnetic compression. Normally the gas is preexcited by the application of r.f. power. Experimental results concerned with devices of the general type described are presented, including the effect on neutron yield of deuterium pressure, magnetic field strength, geometrical and other factors. Additional results of a diagnostic nature are also presented. (auth)

14856 A/CONF.15/P/357
Princeton Univ., N. J. Project Matterhorn.
HEATING OF A CONFINED PLASMA BY OSCILLATING ELECTROMAGNETIC FIELDS. J. M. Berger, W. A. Newcomb, J. M. Dawson, E. A. Frieman, R. M. Kulsrud, and A. Lenard. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

It is found that as far as the heating of the plasma is concerned, there are three characteristic frequencies which play a fundamental role. If these three characteristic frequencies are all of comparable order, the theoretical analysis is exceedingly complex. Therefore, four cases were considered in which these were taken to be of different orders. The heating mechanism differs in each of these four cases since the frequency of the externally produced electric field is chosen to be comparable to one of the characteristic frequencies in the analysis. In each of the four cases configurations were found which led theoretically, at least, to efficient heating of the plasma. In those cases where the energy imparted to the plasma appears in the form of wave motion, the subsequent damping of these waves is discussed. (auth)

14857 A/CONF.15/P/358
Princeton Univ., N. J. Project Matterhorn.
"RUNAWAY" ELECTRONS AND COOPERATIVE PHENOMENA IN B-1 STELLARATOR DISCHARGES. W. Bernstein, F. F. Chen, M. A. Heald, and A. Z. Kranz. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Detailed measurements of x rays generated by fast "runaway" electrons striking the discharge-tube wall proved to be a valuable diagnostic device in investigating the behavior of a high-temperature plasma. The quantities measured were the energy spectrum, time of occurrence, and relative intensity of the x rays emitted from helium discharges in the B-1 stellarator with various combinations of the discharge parameters; their relationship to other characteristics of the discharge was studied. (auth)

14858 A/CONF.15/P/359
Princeton Univ., N. J. Project Matterhorn.
THE DIVERTOR, A DEVICE FOR REDUCING THE IMPURITY LEVEL IN A STELLARATOR. C. R. Burnett, D. J. Grove, R. W. Palladino, T. H. Stix, and K. E. Wakefield. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A divertor, designed to reduce the flow of impurities from the wall back into a gas discharge, was used with a small stellarator. The magnetic design of this device is described, and the theory of its performance is outlined. Spectroscopic data are given on the impurity level in the plasma with and without the divertor activated. (auth)

14859 A/CONF.15/P/360
Princeton Univ., N. J. Project Matterhorn.
EXPERIMENTS ON ION CYCLOTRON RESONANCE.
T. H. Stix and R. W. Palladino. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experiments are performed on the generation of ion cyclotron resonance effects in a stellarator. The data are analyzed in terms of the resolution of the observed resonance and the energy transfer to the plasma. (auth)

14860 A/CONF.15/P/361
Princeton Univ., N. J. Project Matterhorn.
GENERATION AND THERMALIZATION OF PLASMA WAVES. T. H. Stix. 23p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Using linearized hydromagnetic equations, the energy transfer to a cylindrical low temperature plasma in a uniform axial magnetic field from an external forcing coil is calculated. Ion cyclotron and hydromagnetic waves are generated. Of particular interest is the thermalization of the ion cyclotron waves via a cyclotron damping effect. (auth)

14861 A/CONF.15/P/362
Princeton Univ., N. J. Project Matterhorn.
and [General Atomic Div.,] General Dynamics Corp., San Diego, Calif.
EXPERIMENTS ON THE OHMIC HEATING AND CONFINEMENT OF PLASMA IN A STELLARATOR.
T. Coor, S. P. Cunningham, R. A. Ellis, M. A. Heald, and A. Z. Kranz. 27p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Plasmas of helium and hydrogen confined in a stellarator have been subjected to ohmic-heating pulses. Observations on the variation of electron and ion temperatures, and plasma density and composition both during and after the heating pulse are given. The effects of impurities, run-away electrons, and cooperative phenomena are discussed. (auth)

14862 A/CONF.15/P/363
Princeton Univ., N. J. Project Matterhorn.
ON THE IONIZATION AND OHMIC HEATING OF A HELIUM PLASMA. J. M. Berger, I. B. Bernstein, E. A. Frieman, and R. M. Kulsrud. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A method used for the ionization and heating of helium plasmas in various Stellarator models consists of inducing an approximately constant electrical field along the main axial confining field. The details and results of various calculations pertaining to this method are presented. The gas is assumed initially to be 10% ionized and at a temperature of a few electron volts. The major approximations on which the calculations are based are: (1) Maxwellian velocity distributions for the particles and, (2) negligible charged particle loss across the confining magnetic field. The equations for the power balance and number balance were integrated in time numerically for a variety of initial conditions. The results indicate that temperatures of a few hundred electron volts are attainable within milliseconds with an applied field of the order 0.1 volt per cm at densities of 3×10^{13} particles per cm^3. It was found that the maximum temperature is limited by power loss in bremsstrahlung radiation. (auth)

14863 A/CONF.15/P/364
Princeton Univ., N. J. Project Matterhorn.
HYDROMAGNETIC INSTABILITY IN A STELLARATOR.
M. D. Kruskal, J. L. Johnson, M. B. Gottlieb, and L. M. Goldman. 21p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The theory of hydromagnetic instability is applied to the magnetic configuration of a stellarator, when a current is flowing parallel to the tube axis. Results are given primarily for the mode m = 1, where the disturbance is assumed to vary over the cross section of the discharge as cos $m\theta$ times some function of r, the distance from the tube axis. For this mode it is shown that the plasma is stable, provided that the mean current density is less than a critical value, which varies proportionally with the axial magnetic field; for greater current densities the plasma is unstable. Comparison of these predictions with the observations on various stellarators indicates that the data are fully consistent with the theory; strong instabilities appear at a critical current, which varies with conditions in close agreement with the theory. Theory predicts also the appearance of instabilities for higher values of m at lower values of the current, but there is no clear observational indication for these higher-mode instabilities. (auth)

14864 A/CONF.15/P/365
Princeton Univ., N. J. Project Matterhorn.
ON THE STABILITY OF PLASMA IN STATIC EQUILIBRIUM. M. D. Kruskal, and C. R. Oberman. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Criteria useful in the discussion of stability of plasmas in static equilibrium are derived from the Boltzmann equation in the small m/e limit. Collisions are ignored at first, but later it is shown how their effects are taken into account. This approach yields a generalization of the usual energy principles for investigating the stability of hydromagnetic systems to situations where the effect of heat flow along magnetic lines is not negligible, and hence to situations where the strictly hydrodynamic approach is inapplicable. The general method of approach is characterized. The properties of the small m/e limit used in the problem, the constants of the motion, and the conditions for static equilibrium are delineated. The first and second variations of the energy are calculated and a statement of the general stability criterion is given. Several theorems are stated which relate the stability criterion of the problem to those of ordinary hydromagnetic theory. The effect of collisions is considered. The remaining problem of incorporating the charge neutrality condition into the present stability theory is stated briefly. (M.R.H.)

14865 A/CONF.15/P/366
Oak Ridge National Lab., Tenn.
DIFFUSION OF ARC PLASMAS ACROSS A MAGNETIC FIELD. Albert Simon. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

It is shown that the anisotropic conductivity in plasma produces a diffusion across the magnetic field which is not ambipolar. The ions and electrons, instead, diffuse at their own instrinsic rates. Space-charge neutralization is maintained by slight adjustments of the currents in the direction of the field lines. These results are

compared with the experiments of Bohm, Neidigh, and Bickerton. The analysis is valid only for the case of a weakly ionized gas. The effects of providing magnetic mirrors at the ends of the arc and the effect of increasing the tube length in the direction of the field lines are considered. (M.H.R.)

14866 A/CONF.15/P/367
Stevens Inst. of Tech., Hoboken, N. J.
PROPULSION OF PLASMA BY MAGNETIC MEANS. William H. Bostick. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

It has been demonstrated that plasma consisting of Ti ions, deuterium ions, and electrons can be propelled by a small button plasma gun (or "motor") at speeds up to 2×10^7 cm/sec. This gun's forces last only a fraction of a μsec, so rail-type guns and rail-type guns wrapped into a circle or helix are studied. Among the "plasma motors" discussed are the series, the combination series-shunt, rotary shunt, and a barrage of button guns. (M.H.R.)

14867 A/CONF.15/P/369
California. Univ., Livermore. Radiation Lab.
THE STABILIZED PINCH. S. A. Colgate, J. P. Ferguson, and H. P. Furth. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Complete stability can be achieved by entrapment of an axial magnetic field H_z in the pinch column, provided a number of secondary conditions are met. The pinch radius must be kept larger than $\frac{1}{3}$ the radius of the return-conductor shell, and the plasma pressure must be low compared to $H_z^2/8\pi$. The region containing hot plasma and H_z field must be sharply bounded from that containing the pinch field H_θ. These theoretical stability criteria were tested in linear pinch experiments. Apparently stable pinches were formed under the prescribed conditions. Under improper conditions, in particular for substantial H_z appearing in the H_θ-field region, the helical instability mode was induced. The magnetic field behavior in time and space was studied by means of magnetic probes. The occurrence of instabilities was observed synchronously with probes and with optical equipment. The sign of the helical instability was shown to depend on the direction that H_z has in the H_θ-field region. The interdiffusion of the H_z and H_θ regions was found to proceed at a rate indicative of plasma temperatures up to 50 ev. Similar temperatures were derived from pressure balance analysis of the magnetic probe data. These results corresponded closely to calculated equilibrium temperatures for plasma in thermal contact with cold electrodes. To achieve higher temperatures and so impede resistive interdiffusion of the H_z- and H_θ-field regions, experiments are now conducted in toroidal geometry. The pinch current is generated by induction, and the drainage of heat electrodes is eliminated. The basic problems of plasma heat generation and loss can thus be studied. (auth)

14868 A/CONF.15/P/372
California. Univ., Livermore. Radiation Lab.
A PARTLY STABILIZED DYNAMIC PUNCH. S. A. Colgate, J. P. Ferguson, H. P. Furth, and R. E. Wright. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The standard dynamic pinch is subject to sausage (or m = 0) instabilities which grow nonlinearly and effect the rapid self-destruction of this pinch configuration. The stabilizing axial field is applied externally to the plasma column. Preliminary experiments conducted with a 20,000 joule source show the expected hydrodynamics and instability pattern. First bounce time in 100 microns deuterium was reached at 0.7 μsec, and m = 1 instability breakup was observed at 1.5 μsec. Neutron pulses of about 10^5 were recorded coincident with the m = 1 instability rather than with the applied voltage. The neutron yield was unaffected by the presence of substantial fractions of helium, but disappeared totally at 300 microns starting pressure. The mechanism of production is not completely understood, but it is thought that Fermi-type acceleration of fast deuterons rather than bulk heating of the plasma might account for the yield observed. A larger energy source is being applied to the further study of this configuration. (auth)

14869 A/CONF.15/P/373
California. Univ., Berkeley. Radiation Lab. and California. Univ., Livermore. Radiation Lab.
STUDY AND USE OF ROTATING PLASMA. Oscar A. Anderson, William R. Baker, Alexander Bratenahl, H. P. Furth, John Ise, Jr., W. B. Kunkel, and John M. Stone. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A preliminary report is given on the homopolar device (axial magnetic field with radial electric field), which is the rotating plasma configuration most thoroughly investigated thus far. The analysis presented applies principally to the "ideal" homopolar, i.e., the configuration free from electrode-sheath drops and other disturbing but remediable phenomena. The experiments described were carried out mostly under high-density (pinch-type) conditions which favor the creation of a totally rotating plasma. (M.H.R.)

14870 A/CONF.15/P/374
New York Univ., New York. Inst. of Mathematical Sciences.
HYDROMAGNETIC SHOCK WAVES IN HIGH-TEMPERATURE PLASMAS. C. S. Gardner, H. Goertzel, H. Grad, C. S. Morawetz, M. H. Rose, and H. Rubin. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

It is proposed to establish that something like the gyro radius governs the shock transition under appropriate circumstances. The extreme case of infinite mean-free-path with no collisions between particles is treated. It is found possible to choose conditions such that the shock will heat the ion gas much more than the electron gas. A number of approximate two-fluid theories for the mathematical problems are described, also several approximations to a complete self-consistent field solution, as well as combinations of fluid and particle analysis. The cumulative evidence seems to be quite strong for the existence of shock waves with the properties described. (M.H.R.)

14871 A/CONF.15/P/376
New York University, New York. Inst. of Mathematical Sciences.
PROBLEMS IN MAGNETOHYDRODYNAMIC STABILITY. J. Berkowitz, H. Grad, and H. Rubin. 24p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The problem considered is to stabilize a pinched plasma cylinder by applying alternating external mag-

netic fields. Rosenbluth and Tayler have found statically stable equilibrium configurations, but it is worthwhile to investigate different stabilizing mechanisms, since it may be necessary to compress the plasma to an extent which takes it outside the domain of stability in the Rosenbluth-Tayler stability diagram. It is supposed that the external coils and currents are so arranged that, at each point of the plasma boundary, the magnetic field is of constant magnitude and rotating with constant angular velocity in the tangent plane to the plasma boundary. The specific model investigated is a perfectly conducting plasma supported against a gravity-like force by a horizontal, magnetic field whose direction varies in time. This equilibrium configuration is known to be unstable in the static case. The stability analysis leads to a study of Mathieu's differential equation. The main result is that the application of alternating fields does not produce stability—indeed, instabilities may be excited by applying alternating fields even in statically stable configurations. However, in a case which is statically unstable, there is a definite stabilizing tendency, namely, in producing a finite upper bound to the growth rates. (auth)

14872 A/CONF.15/P/378
California. Univ., Livermore. Radiation Lab.
PYROTRON PLASMA-HEATING EXPERIMENTS. F. H. Coensgen and F. C. Ford. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experiments directed toward the heating of a plasma by means of time varying magnetic fields were conducted in a series of pyrotron apparatuses of widely varying geometries. In these experiments, bursts of plasma at a relatively low temperature are created within the confinement volume and are then subjected to strong magnetic heating effects. At the end of the heating operation the plasma has become sufficiently hot to generate x rays, strong microwave noise signals and other high temperature phenomena. Under the proper conditions it can be shown that heated components of the plasma remain stably confined for many milliseconds, a time which increases with the degree of heating. It is also possible to induce an instability in the plasma such that the confinement time becomes relatively short. Measurements indicative of time resolved plasma temperature, density, composition and spatial distribution are described. Although it was not possible to document details of the plasma energy and density distribution completely, it has been possible to establish several critical conditions for the production, heating and stable confinement of a hydrogenic plasma and experimentally to demonstrate the general validity of the pyrotron theory. (auth)

14873 A/CONF.15/P/379
California. Univ., Livermore. Radiation Lab.
PYROTRON HIGH-ENERGY EXPERIMENTS. C. C. Damm and F. S. Eby. 4p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experiments were performed to explore the creation and confinement of a high temperature plasma produced by the trapping of beams of energetic particles originating outside of a magnetic confinement volume. This method of creating a hot plasma has the advantage that the initial heating problem is eliminated. Its application, however, presents substantial problems of a fundamental kind, as well as practical problems of vacuum technique and high-current particle source technology. In the investigations several aspects of the theory are compared with the results of experimental studies of the initial behavior of the injected particles and their subsequent confinement. (auth)

14874 A/CONF.15/P/380
California. Univ., Livermore. Radiation Lab.
INJECTION INTO THERMONUCLEAR MACHINES USING BEAMS OF NEUTRAL DEUTERIUM ATOMS IN THE RANGE FROM 100 KEV TO 1 MEV. G. Gibson, W. A. S. Lamb, and E. J. Lauer. 3p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The injection scheme described is of the type in which trapping is accomplished within a steady confining magnetic field configuration by means of an increase in the e/m of the particles. A beam of neutral deuterium atoms is sent into the mirror machine normal to the field line and in the symmetry plane. A fraction of the atoms are trapped in the field as a result of being ionized by collisions with either cold neutral atoms or trapped hot ions. (M.H.R.)

14875 A/CONF.15/P/381
California. Univ., Livermore. Radiation Lab. and Stanford Research Inst., Menlo Park, Calif.
PLASMA DIAGNOSTIC DEVELOPMENTS IN THE UCRL PYROTRON PROGRAM. C. B. Wharton, J. C. Howard, and O. Heinz. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In the investigation of plasma confined in the various embodiments of pyrotrons several special plasma diagnostic techniques were developed and applied. Methods were developed whereby microwave beams propagated across the confining magnetic fields are used to measure plasma density. Microwave noise signals emitted from the plasma were used in deducing something about the electron temperature and density of the plasma. Because charged particles cannot easily escape across magnetic field lines, methods were devised to detect and analyze the escape of energetic neutral particles created through charge exchange processes under controlled conditions. Such measurements give an indication of plasma confinement and temperature. Well established spectroscopic methods were also applied to measure the purity, state of ionization and ion energies in the confined plasmas. (auth)

14876 A/CONF.15/P/383
California. Univ., Berkeley. Radiation Lab. and California. Univ., Livermore. Radiation Lab.
INDIVIDUAL PARTICLE MOTION AND THE EFFECT OF SCATTERING IN AN AXIALLY SYMMETRIC MAGNETIC FIELD. A. Garren, R. J. Riddell, L. Smith, G. Bing, L. R. Henrich, T. G. Northrop, and J. E. Roberts. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Two aspects of the behavior of a collection of charged particles in an axially symmetric magnetic-field configuration were studied. The first involves the trajectories of particles in this field configuration in the absence of collisions with other particles. By analytic and numerical methods these trajectories were studied and several different types observed. The other aspect involves interparticle Coulomb collisions. The equations derived by other authors were numerically solved for several cases of interest. Details of the calculations and a discussion of the results are presented. (auth)

14877 A/CONF.15/P/385
Stanford Research Inst. Poulter Labs. Menlo Park, Calif.
THEORY OF MICROWAVE DIAGNOSTICS OF HOT

PLASMAS. James E. Drummond. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The theory of the microwave properties of plasmas in a magnetic field is reviewed. Special emphasis is given to transconductance, which permits microwave transmission measurements in very dense, high temperature magneto-plasmas. This property arises because of the partial spanning of a wave length by the electron orbits. Even though the current density in one small volume of the plasma is then determined by the electromagnetic field throughout other regions, a complete set of eigenfunctions for the electromagnetic field was found, for each of which Ohm's law is valid within every volume element of the plasma. The eigenvalues associated with these functions are plasma conductivity tensors. Superpositions of the functions show the penetration and transmission characteristics of probing microwave signals. A number of special cases of interest that were worked out in detail are described. (auth)

14878 A/CONF.15/P/387

Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics.

MICROWAVE STUDIES OF GAS DISCHARGE PLASMAS. S. C. Brown. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The interaction of microwave electromagnetic radiation and the plasma of gas discharges was the subject of a great deal of research for many years. A survey of the usefulness of this technique as applied to intensely ionized plasmas is presented. Particular attention is given to the microwave technique as a diagnostic tool in determining plasma densities including a survey of the various types of microwave probes and their experimental limitations. The use of microwave power does not appear likely to produce high-density plasmas; however, stable low-pressure microwave plasmas in magnetic fields provide a good method for measuring the fundamental behavior of gas discharge phenomena of interest in controlled thermonuclear plasmas, and studies along these lines are reported. The applicability of the microwave method in studying electron collision cross sections, and recombination and diffusion processes in magnetic fields are also discussed. (auth)

14879 A/CONF.15/P/1025

Los Alamos Scientific Lab., N. Mex.

LOW VOLTAGE-GRADIENT PINCHES IN METAL-WALLED SYSTEMS. D. A. Baker, G. A. Sawyer, and T. F. Stratton. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Studies were made of high current pinched discharges in deuterium gas. Voltage gradients were one to five volts per cm, initial gas pressures were 0.1 to 10 microns Hg and axial magnetic fields were 500 gauss maximum. Metal walled, linear discharge tubes of 15 cm diameter tube was also assembled as an electrodeless, endless square with elbows at the corners, and excited as an air-core transformer. Current-voltage characteristics, high speed photography, time resolved spectra, and magnetic probe measurements were the principal diagnostic techniques. The magnetic field distributions obtained with the magnetic probes showed an oscillation in time and space for certain combinations of gas density, gas current, and applied axial magnetic field. It was possible to derive complete current distributions in this case from the time and radial dependence of the three components of magnetic field. The current distribution was found to show a helical notch of reduced current density which rotated with uniform angular velocity. The helical regularity appeared to be a superposition of hydromagnetic waves of the Alfven type travelling in the z and θ directions with velocities approximately equal to sound velocity in the plasma. Hydromagnetic waves with motion perpendicular to H_0 at approximately sound velocity were considered by Cowling. (auth)

14880 A/CONF.15/P/1064

California. Univ., Berkeley. Radiation Lab. and California. Univ., Livermore. Radiation Lab.

A SUMMARY OF THE BERKELEY AND LIVERMORE PINCH PROGRAMS. W. R. Baker and S. A. Colgate. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Work on the following phases of the pinch program is summarized: stabilized pinch, sheet pinch devices, homopolar, shock heating-collapse, and the screw dynamic pinch. (M.H.R.)

14881 A/CONF.15/P/1538

New York Univ., New York. Inst. of Mathematical Sciences.

CUSPED GEOMETRIES. J. Berkowitz, K. O. Friedrichs, H. Goertzel, H. Grad, J. Killeen, and E. Rubin. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

For the thermonuclear application, studies and quantitative computations were made of possible methods of operation, methods of heating and initiation, simple exploratory experiments, and particle loss rates. The general conclusion is that there seems to be no over-riding advantage to either the conventional or the cusped geometries. The chief advantage of the latter is absolute stability; e.g., operated as a pinch a cusped configuration allows stable compression of arbitrary magnitude as compared to the limited compression which is allowed for the B_z-stabilized pinch. On the other hand, particle losses in general tend to be higher in the cusped geometries and magnetic field energy is not used efficiently, but the situation is complex because of the plethora of alternatives, each of which has its own advantages and disadvantages. (auth)

14882 A/CONF.15/P/1765

New York Univ., New York. Inst. of Mathematical Sciences.

THERMONUCLEAR REACTION RATE IN A DISCHARGE. H. Grad. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The electrical conductivity of a plasma is found by computing the deviation from Maxwellian of the electron distribution produced by an external electric field. For computing the thermonuclear output, the high-velocity, non-Maxwellian tail of the ion distribution cannot be evaluated by conventional methods. The reason is that although the bulk of the distribution may be only slightly perturbed from a Maxwellian, the tail end is violently perturbed. Such difficulties are avoided by making use of special features of the Fokker-Planck equation and by introducing an asymptotic expansion in the electron-ion mass ratio. (M.H.R.)

14883 A/CONF.15/P/1790

Oak Ridge National Lab., Tenn.

STUDIES OF INTENSE GAS DISCHARGES. J. S. Luce. 30p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The properties of several new arc types, requiring an axial magnetic field, are investigated. Topics covered include: the development of discharges without defining electrodes and the discovery of the energetic carbon arc, a qualitative description of the energetic carbon arc, and the properties, applications, and the techniques of operation of the energetic carbon arc. The development of high-current molecular ion sources and types of energetic deuterium arcs are also discussed. (M.H.R.)

14884 A/CONF.15/P/1861
Los Alamos Scientific Lab., N. Mex.
THE STATIC PINCH. Conrad L. Longmire. 2p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In a pinch, the outward diffusion of plasma due to collisions can be balanced by the inward drift resulting from $\vec{E} \times \vec{B}$, where $\vec{E}$ is the applied electric field and $\vec{B}$ the magnetic field. From the equation expressing the balance of these two effects, and from the pressure-balance equation, one can deduce the so-called perpendicular conductivity which turns out to be about one-half of the classical (parallel) conductivity. This result has been applied to the problem of a static pinch in the presence of an applied longitudinal magnetic field. It turns out that the plasma can have a sharp outer edge which is not in contact with the wall, in spite of the diffusion. The plasma distribution, however, is unconditionally unstable according to Suydam's criterion for interchange instability. An attempt to find a distribution with an unstable core but with a stable envelope has been unsuccessful. (auth)

14885 A/CONF.15/P/1875
Princeton Univ., N. J. Project Matterhorn.
SOME STABLE HYDROMAGNETIC EQUILIBRIA. J. L. Johnson, C. R. Oberman, R. M. Kulsrud, and E. A. Frieman. 40p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A large class of nonaxisymmetric equilibrium configurations is determined by an expansion procedure applied to the usual equations which govern hydromagnetic equilibria. The expansion is made in the small quantities, β, δ, and η, where β is the ratio of the maximum plasma pressure to the magnetic pressure, δ characterizes the deviation of the externally-produced magnetic field from that of the cylinder, and η characterizes the strength of the longitudinal currents which may be assumed to be driven through the plasma by external emf's. Various properties of these equilibria are presented. (auth)

14886 A/CONF.15/P/1876
Princeton Univ., N. J. Project Matterhorn.
EQUILIBRIUM OF A MAGNETICALLY CONFINED PLASMA IN A TOROID. M. Kruskal and R. Kulsrud. 23p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A relatively simple set of equations uniquely determining a quiescent equilibrium of electromagnetic field and continuously replenished diffusing plasma is derived from the steady-state form of a rather general set of plasma equations. The plasma is confined to a closed tube of toroidal topology but otherwise arbitrary geometry. The final set consists of the familiar hydromagnetostatic equations $\nabla p = \underline{j} \times \underline{B}$, $\nabla \times \underline{B} = \underline{j}$, and $\nabla \cdot \underline{B} = 0$ together with two integral conditions over each surface of constant pressure p. Various properties of solutions of these equations are derived. First some simple immediate consequences of the hydromagnetostatic equations are obtained. Then a number of quantities associated with each surface of constant pressure are defined, such as the included volume, magnetic energy, magnetic fluxes, and electric currents. The theory of certain simple systems of differential equations on the constant pressure surfaces is developed. A variational principle for solutions of the hydromagnetostatic equations is established. The principle is suggested heuristically by an imagined experiment in which an ideal viscous hydromagnetic fluid exhibits a damped motion until it comes to rest in an equilibrium configuration. A number of invariants with respect to any such motion is described. These lead to constraints on the admissible trial configurations when the variational principle is formulated. (auth)

14887 A/CONF.15/P/2170
Princeton Univ., N. J. Project Matterhorn.
THE STELLARATOR PROGRAM. L. Spitzer. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The basic concepts involved in the confinement and heating of a gas in a stellarator are outlined. Basically, the confinement scheme consists of modifying the magnetic field so that a single line of force, followed indefinitely, generates not a single circle but rather an entire toroidal surface, called a "magnetic surface." The tube enclosing the gas is, ideally, one of these surfaces, enclosing an entire family of such magnetic surfaces. It is shown that such surfaces can be produced, to a high approximation. The confinement of a plasma in a system characterized by magnetic surfaces is discussed. Heating of the gas is treated; the techniques considered involve heating to intermediate temperatures (about 10^6 degrees K) by currents flowing parallel to the confining magnetic field, and subsequent heating to very high temperatures by means of a pulsating magnetic field, with a wide variety of possible pulsation frequencies. (M.H.R.)

14888 A/CONF.15/P/2292
Los Alamos Scientific Lab., N. Mex.
ON THE THEORY OF RUN-AWAY ELECTRONS. H. Dreicer. 29p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The problem of electrons moving through an infinite gas of positive ions under the influence of a static uniform electric field of arbitrary strength is treated. The assumptions that steady state electron velocity distribution is attained several mean free collision times after the electric field is applied, and that the terminal electron drift velocity is small compared to the average random electron speed are avoided. The problem is formulated starting with the Boltzmann equation, and approximate analytic solutions are reviewed. A time-dependent numerical solution to the Boltzmann equation is described and compared with the approximate solutions. It is concluded that the problem does not admit a time independent solution. Because of the strong energy dependence of the Rutherford scattering law the electron drift velocity is not bounded by a terminal value but grows monotonically with time. This is the runaway effect. Collective effects or plasma oscillations are ignored. (T.R.H.)

14889 A/CONF.15/P/2348
Los Alamos Scientific Lab., N. Mex.
ALL METAL DISCHARGE TUBE WALL. J. A. Phillips and J. L. Tuck. 6p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Contamination of the discharge gas by atoms from the wall produced by sputtering or volatilization is discussed. The temperature rise of a surface for an energy flux is far lower for metals than for even the most refractory insulators. The concept of a continuous spiral metal wall is discussed and it is shown experimentally that good pinches can be formed at high gradients. Furthermore, it is possible by appropriate choice of the sign of the spiral for the rising axial magnetic fields it produces to be helpful to stability. (M.H.R.)

14890 A/CONF.15/P/2349
California. Univ., Berkeley. Radiation Lab.
SHEET PINCH DEVICES. Oscar A. Anderson, William R. Baker, John Ise, Jr., Wulf B. Kunkel, Robert V. Pyle, and John M. Stone. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

It is predicted theoretically that a current-carrying plasma sheet of infinite extent possesses positive stability for some perturbation modes and at least neutral stability for others. This stability is approached in sheet pinch devices of modest size. Both the flat sheet and the cylindrical, edgeless configuration (the latter having been given the name "Triax") will be discussed. Heat transfer to the electrodes was shown theoretically and experimentally to be small. Magnetic probes have been used to determine current density distributions under a variety of conditions, and particle pressures have been calculated therefrom. Time-resolved spectroscopic observations primarily in the visible, are reported and the conclusions drawn are given. These results are interpreted in terms of the dynamics of the discharge and attempts are made to correlate them with temperature and particle-density estimates. Neutrons are produced in discharges of low initial pressure and high peak current when the current is suitably programmed. The possibility of thermonuclear and other methods of neutron production is discussed. (auth)

14891 A/CONF.15/P/2358
Vitro Engineering Co., New York.
ENGINEERING ASPECTS OF A THERMONUCLEAR POWER PLANT. L. Geller, R. W. Kupp, and S. Koslov. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A conceptual design of a thermonuclear central station is developed on the basis of elementary plasma behavior in a confining magnetic field. The D-D reaction is the prime energy source. The plasma containment problem is assumed to have been solved. A gross economics-engineering evaluation of the reactor is presented. (M.H.R.)

14892 A/CONF.15/P/2394
Los Alamos Scientific Lab., N. Mex.
COLUMBUS II (A HIGH POWERED LINEAR PINCH MACHINE). J. W. Mather and A. H. Williams. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The linear pinch machine, Columbus II, with discharge tube 30 cm long and 10 cm I.D., is designed to operate at 100 kv, 1.5×10^6 amperes discharge current and 2 microseconds rise time. Operation is limited above 60 kv and 36,000 joules by failure of the discharge to start break away from the tube wall. Experimental evidence for this process is presented. The effect of an axial magnetic field on the production of neutrons suggests that several mechanisms are responsible for the observed neutrons. Typically 100, 500, and 4,500 gauss decrease the neutron production by a factor of 3, 10, and ~100, respectively, from the zero gauss yield. Peak yields of 6×10^8 neutrons for burst were measured at 40 kv (16,000 joules). The axial neutron energy measured at the cathode decreases with increasing B_z, 2.72 Mev (zero field), 2.58 Mev (100 gauss) and 2.55 Mev (500 gauss). The significance of the neutron energy shift and the high neutron yields are discussed in terms of simple pinch models. (auth)

14893 A/CONF.15/P/2395
Los Alamos Scientific Lab., N. Mex.
FIELD CONFIGURATIONS AND STABILITY STUDIES OF A LINEAR DISCHARGE. L. C. Burkhardt and R. H. Lovberg. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A detailed study of the distribution of magnetic fields in a stabilized linear pinched discharge (Columbus S-4) has demonstrated a tendency of the discharge to lock its magnetic energy inside the tube through ionization of gases remaining external to the pinch. This effect is seen as a circulation of currents in the tube, in some cases reaching half the peak value of the discharge current even though the current from the external capacitor bank has returned to zero. It is shown through elementary arguments that this effect should be most pronounced for discharge tubes of large bore, coupled to short-period capacitor banks. Analysis of the discharge spectrum shows a remarkable absence of electrode materials in the discharge, even though wall elements are abundant. Measurement of plasma pressure distribution indicates much less cooling near the electrodes than simple theory would suggest. Instability studies indicate that small-area surface instabilities persist after sufficient B_z has been applied to remove the gross pinch instabilities. The conditions present in the tube will be compared with the stability criteria of B. R. Suydam. (auth)

14894 A/CONF.15/P/2396
Oak Ridge National Lab., Tenn.
THE EFFECT OF AN APPLIED PRESSURE GRADIENT ON A MAGNETICALLY COLLIMATED ARC. R. V. Neidigh and C. H. Weaver. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Some properties of a gaseous arc of special nature were explored experimentally. The arc runs parallel to the lines of force in a uniform magnetic field. Gas is introduced near a hot cathode, and the arc runs toward a floating therminal electrode. When the pressure in the region of the main part of the column is reduced to the neighborhood of 10^{-5} mm Hg, the plasma and the potential distribution a short distance from the arc column are found to rotate about the arc column with a frequency of 25-50 kc, while in the region close to the column, rotation at a higher frequency takes place in the opposite direction. (auth)

14895 A/CONF.15/P/2430
California. Univ., Livermore. Radiation Lab.
TRANSIENT TEMPERATURE VARIATIONS DURING THE SELF-HEATING OF A PLASMA BY THERMO-

NUCLEAR REACTIONS. Howard D. Greyber. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The transient temperatures to be expected in an idealized physical situation that still bears some resemblance to a controlled thermonuclear reactor are traced. A system is assumed for the calculations that is completely open to neutrons and radiation and closed as far as loss of charged particles or any other form of energy drain other than neutrons and radiation is concerned. One qualitative result is that it would be unsafe to assume nuclear temperature always equal to or greater than electron temperature in a discussion of plasma instabilities for a plasma with tritium concentration equal to or greater than 10%. (M.H.R.)

14896 A/CONF.15/P/2446
California. Univ., Livermore. Radiation Lab.
ASTRON THERMONUCLEAR REACTOR. N. C. Christofilos. 28p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Astron reactor is contemplated as accomplishing the requirements for controlling a thermonuclear reaction by a long cylindrical layer of rotating relativistic electrons (E-layer). It is shown that the E-layer is a necessary condition to obtain an equilibrium solution of the plasma in steady state, such equilibrium solution satisfying hydrodynamic, diffusion, and Maxwell's equations. (T.R.H.)

14897 A/CONF.15/P/2488
Los Alamos Scientific Lab., N. Mex.
OPERATIONAL CHARACTERISTICS OF THE STABILIZED TOROIDAL PINCH MACHINE, PERHAPSATRON S-4. J. P. Conner, D. C. Hagerman, J. L. Honsaker, H. J. Karr, J. P. Mize, J. E. Osher, J. A. Phillips, and E. J. Stovall, Jr. 30p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Perhapsatron S-4 machine has a quartz torus, 14.0-cm minor inside diameter, 218-cm mean circumference, and wall thickness 0.6 cm. An aluminum primary, 1.25-cm thick surrounds the quartz torus with minimum spacing, ~0.4 cm, and can be energized by 90,000 joules, 20 kv at two feed points, permitting a maximum electric field of 150 volts/cm. A two-ton iron core (laminations 0.002-inch thick) links the primary and secondary and has a rating of 0.2 volt-sec. A solenoid, 1.6 turns per cm, wound around the primary is energized by a 2400 μf capacitor at voltages up to 3 kv and produces an axial B_z magnetic field up to 4000 gauss. A split in the aluminum primary allows rapid B_z field penetration. The typical behavior of gas current and secondary voltage at 25 kv is shown. The current-voltage phase relation shows that the gas current is largely inductance limited and not resistance limited as observed in PS-3. After gas breakdown ~80% of the condenser voltage appears around the secondary in agreement with the ratio of source and load inductances. The rate of rise of gas current at first is large, $\sim 1.3 \times 10^{11}$ amps/sec, until the gas current contracts to cause an increase in inductance at which time the gas current is a good approximation to a sine curve. The gas current maximum is found to rise linearly with primary voltage, deviating as expected at the higher voltages because of iron core saturation. At the discharge current maximum, the secondary voltage is not zero, and if one assumes that there is no large change of inductance, the total resistance of the discharge (R = V/I) is computed to be ~28 milliohms. (auth)

Electrons

14898 A/CONF.15/P/800
High Voltage Engineering Corp., Cambridge, Mass.
TECHNIQUES FOR THE INDUSTRIAL USE OF ELECTRON IRRADIATION. D. A. Trageser. 11p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Three developments are described which bring nearer the economic use of electron processing. Their objectives are (1) to increase the useful penetration of electron beams, (2) to increase the efficiency of absorption, and (3) to apply electron beams to gases and liquids in continuous flow under elevated pressure and temperature. In each case, relatively inexpensive equipment is involved which does not require modification of the basic accelerator. First, inversion of a beam to give double bombardment from one accelerator is adaptable to industrial applications where simultaneous double-side irradiation is desired. Secondly, the use of intermittent filters increases the efficiency of double bombardment to about 80%. Thirdly, new thin-walled reactors and flow tubes can be used for the irradiation of fluids under pressures up to 100 atmospheres and at high temperatures, even with 1 to 4 Mev beams. Efficiencies range from 40 to 95% depending upon the pressure. Pressure drops are small, even at flow rates which are sufficiently high for industrial use. (auth)

14899 A/CONF.15/P/2015
California. Univ., Livermore. Radiation Lab. and California. Univ., Berkeley. Radiation Lab.
ELECTRON TRIPLET PRODUCTION IN HYDROGEN. John D. Anderson, Duane C. Gates, Thomas L. Jenkins, Robert W. Kenney, Charles A. McDonald, Jr., and William P. Swanson. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The production of electron pairs in the Coulomb field of atomic electrons (triplets) in hydrogen was observed in a 4-inch-diameter hydrogen bubble chamber placed in the photon beam of the 340-Mev Berkeley synchrotron. A pulsed magnetic field of 10 kilogauss allowed the momentum of each electron to be determined. Preliminary data for the total cross section are given. The momentum distribution of the recoil negatron integrated over all observed events shows a momentum dependence of $P_R^{-1.76 \pm 0.20}$ in the region above P_R = 0.5 Mev/c. The angular distribution, integrated over all momenta, peaks at 55° (lab) and its shape is approximately symmetrical, with a full width at half maximum of 54 ± 5°. (auth)

Gases

14900 A/CONF.15/P/721
Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tenn.
DEVIATIONS FROM CLASSICAL KINETIC THEORY IN THE LOW PRESSURE TRANSPORT OF GASES THROUGH POROUS MEDIA. A. S. Berman and L. M. Lund. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Low-pressure transport of gases through two porous disks, a capillary, and an orifice was examined. Noble gases were used in the study, and measurements were made of the flow of these gases at several temperatures. The results of these measurements provided information concerning deviations from predictions

based on conventional kinetic theory concepts. The deviations are discussed, and an explanation for this effect is suggested. (J.R.D.)

Isotopes

Refer also to abstract 15146.

14901 A/CONF.15/P/945
Argonne National Lab., Lemont, Ill.
OPTICAL METHODS OF ISOTOPE RATIO DETERMINATION. James K. Brody and Frank S. Tomkins. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In the methods developed for H^1, H^2, H^3 and He^3, He^4, electrodeless discharge tubes were used and the lines resolved with a grating spectrograph. Initially, intensity measurements were made photographically but later improved with direct photoelectric scanning of the spectrum. The Li^6, Li^7 isotope shift in the λ 6707 A line was resolved in the fourth order of a large concave grating spectrograph and also by a Fabry-Perot interferometer. In order to reduce the Doppler broadening of the lines a liquid air cooled hollow cathode tube was developed. The U^{235}, U^{238} isotope pair for the λ 4244.37 A line was resolved directly by the grating. Both the water cooled hollow cathode tube and the high voltage condensed AC spark were used to excite the sample. With the former source, the accuracy of the isotope ratios compared well with the mass spectrometric result. With the spark source, the determinations were made considerably more rapidly but with some sacrifice in accuracy. For small isotope shifts of the order of 0.01 A, a scanning Fabry-Perot interferometer was developed in which the optical path between the plates was varied by changing the pressure. The fringe intensity was measured by a photomultiplier tube, and a typical recorder trace of Pb^{204}, Pb^{206}, Pb^{208} and components of Pb^{207} for λ 4058 is shown. Known mixtures of separated isotopes as well as comparisons with mass spectrometric values for normal lead were used to test the method. Normal mercury was assayed isotopically using the line λ 4047 for the odd, 199/201 ratio and the 2536 line in the tenth order for the even isotope ratios. The results compared favorably with mass spectrometric value for normal mercury. (auth)

14902 A/CONF.15/P/1045
General Motors Corp. Research Staff, Detroit and General Motors Inst., Flint, Mich.
THE OPERATION OF THE GENERAL MOTORS "RADIOISOTOPES IN INDUSTRY" TRAINING PROGRAM. A. Somerville, J. P. Danforth, F. L. Green, and D. F. Pierce. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The over-all isotope research, the training program, the benefits derived from this training program, and the operation of a field study group are discussed in some detail. (W.D.M.)

14903 A/CONF.15/P/1986
Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.
PRODUCTION OF HIGH SPECIFIC ACTIVITY RADIOISOTOPES. A. L. Ayers, W. B. Lewis, and C. E. Stevenson. 28p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The high fluxes of a modern reactor make it possible to produce radioactive materials having many times the specific activity of radium. Calculations of specific activities depend on knowledge of the nuclear parameters of the target, irradiation time, and effective flux. These several effects are treated mathematically, and means for obtaining fairly accurate estimates of the effective radioactive strength of an irradiated sample are presented. Examples of such processing are given. (D.E.B.)

Isotope Separation

14904 A/CONF.15/P/1836
Hooker Electrochemical Co., Niagara Falls, N. Y. and Oak Ridge National Lab., Tenn.
PRODUCTION OF BORON-10. G. T. Miller, R. J. Kralik, E. A. Belmore, and J. S. Drury. 30p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A plant for the production of 40 kilograms per month of elemental boron enriched to 92% in isotope-10 is described. Dimethyl ether–boron trifluoride complex is employed for the separation of the two stable isotopes of boron. Dimethyl ether is produced from methyl alcohol at the plant. The complex is fed into a series of 6 columns constructed of monel which operate as a single column with an effective height of 350 feet and having the equivalent of 380 theoretical plates. A reflux ratio of approximately 700:1 is used. Separation is based on the differential rate of dissociation-reassociation of the B^{10} and B^{11} fluorides with dimethyl ether. A B^{10} enriched complex is removed from the bottom of the column. Conversion of enriched $B^{10}F_3$ complex to elemental boron was carried out by two methods. The earlier method is conversion of the complex with aluminum chloride to BCl_3 followed by reduction with hydrogen on a hot wire. A second more economical method is to convert the complex with potassium fluoride to KBF_4 which is reduced to elemental boron by fused salt electrolysis at approximately 800°C in an electrolyte containing potassium fluoride and potassium chloride. The report discusses engineering and operating problems and outlines production costs. (auth)

Mass Spectrography

14905 A/CONF.15/P/830
Oak Ridge National Lab., Tenn.
PRODUCTION AND DISTRIBUTION OF ELECTROMAGNETICALLY ENRICHED ISOTOPES. P. S. Baker, W. A. Bell, Jr., W. C. Davis, C. V. Ketron, L. O. Love, J. A. Martin, E. B. Olszewski, W. K. Prater, and K. A. Spainhour. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The production and distribution of stable isotopes have been highlighted by the recent separation of dysprosium, erbium, and ytterbium isotopes for the first time. High-purity collections of Li^6, Li^7, B^{10}, and B^{11} have also been carried out using the large electromagnetic separators. The need for samples of ultra-high isotopic purity has led to the development of a high-resolution isotope separator (HRIS). In addition to being suitable for the further enhancement of small quantities of certain isotopes already enriched to 99.99+% in the larger calutron facilities, the unit is capable of enriching U^{235}

from 0.7% in normal uranium to approximately 93% in a single pass. In typical runs, furthermore, the beam current has reached a peak of 4.8 ma, and has averaged 2 ma, with backgrounds of only 2 to 3 μa. The application of the HRIS to heavy element separations as well as to high-purity collections of small amounts of stable isotopes is considered, and the features of the unit responsible for its success is evaluated. (auth)

Mathematics

14906 A/CONF.15/P/633

Knolls Atomic Power Lab., Schenectady, N. Y. and Los Alamos Scientific Lab., N. Mex.

MATHEMATICAL TECHNIQUES IN TWO-SPACE-DEMENSION MULTIGROUP CALCULATIONS. E. L. Wachspress, P. M. Stone, and C. E. Lee. 14p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Reactor design technology includes extensive application of high speed, large memory, digital computer techniques, especially in the evaluation of nuclear characteristics. One of the most valuable engineering and physics tools is the two-space-dimension multigroup calculation which has during the past year undergone a rapid metamorphosis to keep abreast of digital computer development. The first such program, MUG, though hampered by mesh increment and material region limitations, was widely used from 1953 to 1956. Several alternate programs were developed during these years, and various physics concepts were introduced to enable more accurate analysis of a wider range of reactor parameters. In early 1956, the PDQ and CURE programs became available, supplanting previous codes by solving more general problems much more rapidly and at lower cost. Although a major contributing factor to the success of these programs was the faster and larger computer memory available, mathematical iteration technique advances were also of importance. Both Tchebysheff and steepest descent extrapolation parameters are automatically used to combine successive fission distribution iterates so that the number of fission source iterations is reduced considerably in many problems. In PDQ, optimum flux iteration parameters are automatically computed for the Successive Overrelaxation (SOR) scheme, and in CURE, a generalized alternating-direction-implicit scheme has replaced the less rapidly convergent SOR method. The CURE program also adjusts the flux iteration parameters to be consistent with the convergence rate of the fission source distribution. Group dependent neutron fluxes and adjoint-fluxes may be calculated. The CURE program permits a material dependent fission spectrum in order that variations in fission cross-sections which become spectrum variations in the adjoint calculations may be properly taken into account. A perturbation program, CURE-PSP, computes reactivity coefficients from input cross-section increments, and CURE flux and adjoint output as written on tape by the CURE program. This perturbation calculation is used for computing temperature coefficients, effect of local inhomogeneities, prompt generation time, and other significant reactor parameters. Burnout programs, PDQ-TURBO and CURE-BO, enable lifetime studies of reactor characteristics with relatively little manual input preparation between time steps. TURBO considers various isotopic chains whereas BO is restricted to fully enriched reactors with burnable poisons. The burnout and perturbation calculations are at present restricted to few-group problems, these being especially useful for light-water moderated reactors. Control elements consisting of relatively thin thermally black regions have been treated by various methods, all of which take into account the inadequacy of simply diffusion theory near these regions. One useful approach for cylindrical coordinate calculations of reactors with rod banks is the window shade cross-section modification which combines the Hurwitz-Roe absorption-area theory with experimentally determined extrapolated endpoints to yield appropriate few-group constants for regions with control elements. In calculations where the control elements are represented by geometrically thin regions, cross-sections within the elements are modified to effectively replace simple diffusion by more appropriate theories within these control elements. Correlation with experiment has been satisfactory. (auth)

14907 A/CONF.15/P/639

Argonne National Lab., Lemont, Ill.

A SURVEY AND CLASSIFICATION OF TRANSPORT THEORY CALCULATION TECHNIQUES. Erwin H. Bareiss. 25p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The present methods for the computation of the angular distribution of the neutron flux from the Boltzmann transport equation by subordinating them to a more general method, the method of multi-polynomial approximation, and how existing codes have been improved are discussed. The spatial integration of the multi-group transport equation for one or many regions in a reactor cell is carried out. Higher order formulas are introduced, e.g., the Euler two-point summation formula is truncated to an error of order five. Consistency of all methods is demonstrated, and convergence of the iteration procedures is compared. (auth)

14908 A/CONF.15/P/1009

Michigan. Univ., Ann Arbor.

AIR LEAKAGE FROM SEMI-AIRTIGHT BUILDINGS. William K. Luckow and John F. Patterson. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A method for evaluating the airtightness of a building which is semi-airtight, and a theory which utilizes the the results of the measurement to predict the gas leakage out of the building when it is exposed to atmospheric weather conditions has been proposed. The development rests on the assumption that the behavior of leak points may be adequately described by an orifice equation type relation. The practicality of the method has been demonstrated by application to the prediction of the leakage from the Ford Nuclear Reactor Building. The validity of the method has been supported but not unquestionably established by an independent tracer gas measurement of building leakage. The method is applicable to other reactor hazards calculations such as those required to rate a controlled leakage clean-up system. (auth)

14909 A/CONF.15/P/2386

Los Alamos Scientific Lab., N. Mex.

SOLUTION OF THE TRANSPORT EQUATION BY THE S_n METHOD. Bengt G. Carlson, and George I. Bell. 25p. $0.50(OTS).

Prepared for the Second U. N. International Confer-

ence on the Peaceful Uses of Atomic Energy, 1958.

The S_n method is a powerful tool for the analysis and numerical solution of a large variety of reactor problems. Basically, S_n is a finite difference technique which proceeds in the following general way: The continuous angular variable in the transport equation is replaced by a discrete variable, whereupon the transport equation becomes a system of coupled partial differential equations, and, if certain specified conditions are met, a system of equations called the S_n equations. These have a number of desirable properties, in particular, the S_n equations may be readily solved successively. The solution of the S_n system approaches the solution of the transport equation as the number of discrete angles is increased, and the solution of the S_n difference equations converges to the solution of the S_n equations as the space mesh is refined. The transport equation is basically a conservation law and this feature can be carried to the S_n difference equations. The S_n method is then generalized to the cases of multiple velocity groups, inhomogeneous source terms, and geometrics of higher order. To solve the S_n difference equations for the many problem types and physical situations which arise, a number of numerical techniques are required. Many of these are explained, in particular, the basic iteration methods and the procedures used to establish and speed convergence. The accuracy of the S_n method is stated as a function of n, the number of space points, and other parameters. The accuracy of the S_n methods for reactor cell calculations and disadvantage factor calculations is discussed in some detail. Finally, a number of practical topics are reviewed, such as the selection of velocity groups, the problem of choosing cross sections, and the comparison of calculation with experiment. (auth)

14910 A/CONF.15/P/2489

New York Univ., New York. [Atomic Energy Commission Computing Facility].

THE MONTE-CARLO CALCULATION OF RESONANCE CAPTURE IN REACTOR LATTICES. R. D. Richtmyer, R. Van Norton, and A. Wolfe. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The calculation of the resonance escape probability by the Monte Carlo method is treated. The problem is described in general terms and also with reference to a code for the IBM-704 computer. (T.R.H.)

Measuring Instruments and Techniques

Refer also to abstract 14791.

14911 A/CONF.15/P-394

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

AUTOMATIC IN-LINE ANALYZERS FOR RADIOACTIVE CONSTITUENTS IN LIQUID AND GASEOUS WASTE STREAMS. L. C. Schwendiman, H. G. Rieck, and R. A. Harvey. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A problem of considerable importance to radiological health and safety in the nuclear energy age is the measurement and evaluation of radioisotopes in waste stream streams discharged from reactors and from fuel reprocessing plants. Several instruments have been developed and applied to gaseous and liquid waste streams to automatically sample, analyze, and record the important isotopes present. Three such instruments are described. A total beta-emitter recording instrument samples a stream and prepares the sample automatically, presents it to a counter where the sample is counted and the beta particle emission rate recorded. An automatic analyzing monitor was developed which samples a liquid stream, and analyzes it automatically for seven isotopes. Isotopes of Na^{24}, Mn^{56}, Np^{239}, and As^{76} are measured using gamma ray spectrometer methods. Cu^{64} is measured by detecting the annihilation radiation as gamma coincidences. Beta emitters of P^{32} and Si^{31} are determined, after automatic chemical separation, with a proportional counter. Mechanical, chemical, electrical, and electronic features are described. A third instrument analyzes gaseous waste for Ru^{106}, Ru^{103}, and I^{131}. Gamma ray energy discrimination is utilized as well as continuous chemical separations. Radioactive particulate material is differentiated from the pure gaseous and vapor forms of the isotopes of interest. Application of these instruments permits more effective control of radioactive wastes dispersed to the environment. (auth)

14912 A/CONF.15/P/597

Argonne National Lab., Lemont, Ill.

SOME CURRENT TECHNIQUES OF FAST NEUTRON SPECTRUM MEASUREMENTS. W. C. Redman and J. H. Roberts. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A spectrometer employing two methane-filled proportional counters separated by a collimating plate and coupled to a third anti-coincident counter was employed for the measurement of neutron spectra in ZPR-III. Three gas pressures were used to cover the energy range 30 kev to approximately 1 Mev, and the results were encouraging. Ilford-C2 emulsions and Ilford-1 emulsions loaded with specks of Li^6 glass in the median plane were used to measure the neutron spectrum in ZPR-V. Results are presented and analyzed. (M.H.R.)

19413 A/CONF.15/P/646

Brookhaven National Lab., Upton, N. Y.

DELAYED COINCIDENCE ANALYZER FOR SHORT MEANLIFE MEASUREMENTS. A. W. Sunyer. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A technique is described to conveniently measure meanlives of the order of 2×10^{-11} seconds. Meanlife measurements of excited states in Pb^{207}, Hg^{198}, Os^{190m}, Hf^{180m}, Xe^{131}, Te^{122}, and V^{51} are presented. (W.D.M.)

14914 A/CONF.15/P/647

Brookhaven National Lab., Upton, N. Y.

THE APPLICATION OF THE XYZ RECORDER TO RADIATION STUDIES. L. Grodzins. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The coincidence sorter and its use for simple coincidence spectra, decay schemes, neutron capture gamma spectroscopy, and neutron activation studies are described. (W.D.M.)

14915 A/CONF.15/P/680

Argonne National Lab., Lemont, Ill.

NEUTRON DIFFRACTION TECHNIQUES AND THEIR APPLICATIONS. S. S. Sidhu, LeRoy Heaton, and M. H. Mueller. 32p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

With the availability of high-intensity thermal neutron beams, it is possible to use neutron diffraction in much

the same manner as x-ray diffraction. The automatic operation of neutron spectrometers and the recording of diffraction patterns make it possible to obtain a neutron diffraction pattern in a time comparable with that for x rays. Special specimen holders were developed which give practically no coherent scattering of thermal neutrons and a sample of 10 grams can be used. Collimation by slits, monochromatization by metallic and inorganic single crystals, and monitoring by BF_3 or fission counters were among the techniques employed. Auxiliary equipment such as high-temperature furnaces, cryostats, and electromagnets were built to study substances at temperatures that vary from liquid helium to 1000°C, with or without the magnetic field applied. These techniques were developed to make use of certain unique properties of neutrons and nuclei for the study of problems in the fields of nuclear physics, crystallography, magnetic scattering, and the physical structure of materials, i.e., the problems that are either most sensitive or amenable only to neutron diffraction. (auth)

15916 A/CONF.15/P/694

Pennsylvania State Univ., University Park. Osmond Lab.

STUDY OF ANGULAR AND ENERGY DISTRIBUTIONS OF FISSION FRAGMENTS BY MEANS OF A MULTIGRID IONIZATION CHAMBER. R. R. Roy. 8p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The ionization chamber in question consists of two cathodes with grids and an anode at the center with a grid on each side. The anode, which is a thin gold foil, contains a fine deposit of uranium on both sides. The whole system is inserted into a container filled with pure argon. Thermal neutrons bombard the uranium. If there is a fission, the fragments are ejected in nearly opposite directions, that is, one on each side of the anode. The negative ions produced by the fragments are immediately collected by the anode and the pulse due to them after amplification is made to trigger off the time base of an oscillograph. The positive ions of the two fragments, on the other hand, are collected by their respective cathode after a certain delay. The positive ion pulses after suitable amplifications are given to the vertical plate of the oscillograph. The energy of each fragment is deduced from the height of the respective pulse. For the determination of the angle, it can be shown that for each fragment, the time of arrival of the first positive ion to the respective cathode is related to the angle between the direction of emission of the fragment and the direction of the incident particle. This relation can be expressed in terms of quantities which are measured from the photograph of the pulse. The experiment was made entirely automatic in the sense that the fission fragments are made to take their own photographs. In this way 4000 fragments due to 2000 fissions were measured. The results obtained show that the angular distribution of fission fragments of natural uranium bombarded by thermal neutrons is isotropic. (auth)

14917 A/CONF.15/P/729

California. Univ., Berkeley. Radiation Lab.

HIGH-ENERGY PHYSICS WITH HYDROGEN BUBBLE CHAMBERS. Luis W. Alvarez. 4p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Recent experience with liquid hydrogen bubble chambers of 25 and 40 cm diam. in high-energy physics experiments is discussed. Experiments described are: interactions of K^- mesons with protons, interactions of antiprotons with protons, catalysis of nuclear fusion reactions by muons, and production and decay of hyperons from negative pions. (W.D.M.)

14918 A/CONF.15/P/730

California. Univ., Berkeley. Radiation Lab.

ON THE ANALYSIS OF BUBBLE CHAMBER TRACKS. Hugh Bradner and Frank Solmitz. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The relatively high density of the liquids in bubble chambers introduces analysis problems not encountered in cloud chamber physics. Reactions with cross section σ millibarns in hydrogen will occur on the average every $10^4/\sigma$ inches of track. About 3 π-p scatters in the region of 1 Bev are obtained in a 10-in.-diam. hydrogen chamber per minute of Bevatron operation. Meson-proton interactions at Bev energies are frequently inelastic, necessitating highly accurate measurements to distinguish between emitted π^0, $2\pi^0$, n, etc. The ultimate accuracy attainable may be limited by multiple Coulomb scattering, which introduces a fractional momentum uncertainty $\Delta p/p$ of a singly charged track of velocity βc and length l cm in a field of H kilogauss. For a hydrogen bubble chamber $\Delta p/p = 1.6/H\beta\sqrt{l}$; for a propane bubble chamber, $\Delta p/p = 10/H\beta\sqrt{l}$. At present other errors, due to turbulence, varying track age, nonuniform illumination, film distortion, and camera-lens distortion, produce uncertainties much more severe than the ultimate physical limitation. Apparatus has been constructed for rapid scanning of bubble chamber film, and for rapid precision measurement of track coördinates. One type of coördinate-measuring machine is a projection microscope which automatically steers itself along tracks, while the operator initiates x-y coördinate read-outs at arbitrary points along the tracks. These coördinates are used with IBM-704 programs to reconstruct the space angles and momentum components of each track, and then to carry out kinematic-energy and momentum-balance computations for the particles involved in an event. Complete measurement of an event can be achieved within 30 minutes from the time when the event is first observed. IBM programs for analysis of events in the University of California Radiation Laboratory 10-in.-diam. hydrogen chamber normally involve about 10^4 multiplicative operations; similar analyses of events in the 72-in.-long chamber are expected to involve about 10^5 multiplications. Complicated corrections are required for nonuniformity in the magnetic field, and for optical refraction of the 5-in.-thick top glass window of the chamber. (auth)

14919 A/CONF.15/P/730(Rev. 1)

California. Univ., Berkeley. Radiation Lab. and Michigan. Univ., Ann Arbor.

METHODS OF PARTICLE DETECTION FOR HIGH-ENERGY PHYSICS EXPERIMENTS. H. Bradner and D. A. Glaser. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Particle detection instruments may be divided into two classes; devices which see the actual path of the particle, and counting devices which indicate the passage of a particle. Examples of each class are given, the characteristics of each example are tabulated, and the uses for each device are discussed. (D.E.B.)

14920 A/CONF.15/P/733

California. Univ., Berkeley. Radiation Lab.

DEVELOPMENT AND OPERATION OF LIQUID

HYDROGEN BUBBLE CHAMBERS. James Donald Gow. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A series of liquid hydrogen bubble chambers of increasing size has been constructed, culminating in a chamber 72 by 23 by 15 inches. All the chambers use a vapor-phase expansion system, and all are provided with a strong d-c magnetic field. The 10-inch chamber has been in operation for 2 years in conjunction with the Berkeley Bevatron. This chamber uses a transmission illumination system, and refrigeration is provided by evaporating liquid hydrogen. The sensitive volume contains 8 liters of liquid hydrogen. The 15-inch chamber, more recently placed in operation, is a one-window chamber, using a "retrodirective" illumination system in which a single glass surface serves both for illumination and viewing of bubbles. The 15-inch chamber also is cooled by evaporation of liquid hydrogen, and contains 40 liters of liquid in the chamber proper. This device was designed to operate with deuterium as well as hydrogen. The 15-inch chamber was built primarily as an improved research instrument, but was designed to also serve as a scale model of the 72-inch bubble chamber. The 72-inch chamber will come into preliminary operation in the summer of 1958. This chamber is similar in mechanical and optical design to the 15-inch chamber, except for the use of a Joule-Thompson refrigeration cycle to provide the necessary cooling. The design principles and operating experiences pertaining to the large chambers are presented. (auth)

14921 A/CONF.15/P/744

Sloan-Kettering Inst. for Cancer Research, New York. THE CALORIMETRIC DETERMINATION OF LOCAL ABSORBED DOSE. P. Milvy, S. Genna, N. Barr, and J. S. Laughlin. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The development of a calorimetric technique for the determination of the intensity of radiation has been previously reported. This method has been further developed and applied to the measurement of locally absorbed dose. Its use for the determination of the absorbed dose produced in tissue-equivalent material by cobalt-60 gamma rays is reported here. The entire irradiated medium under study is contained in the calorimeter. At the point where the absorbed dose is desired, a small segment of the medium is thermally isolated by means of vacuum gaps which are sufficiently small to prevent any perturbation of the gamma-ray absorption or of the secondary electron equilibrium. Quasi-adiabatic thermal control is maintained continuously. Imbedded in the absorbing segment is a thermistor which responds to temperature changes and whose output is electronically amplified and recorded. The temperature change has been calibrated in terms of the absorbed dose by means of the dissipation of a known amount of electrical energy. The measurements are reproducible with a standard deviation of less than ± one per cent. The absorbing medium employed in the present investigation is fabricated of conducting plastic, and has as its constituents an equal number of carbon and hydrogen atoms. For cobalt-60 gamma rays it is closely tissue-equivalent. The major correction is for the energy absorbed in the crystal-lattice which does not appear as thermal energy, but as potential energy of chemical configuration. The results of Lawton et al. on the radiolysis of polyethylene were used to calculate a 2.36 per cent correction for the absorbed energy which is not thermally degraded. In addition to the calorimetric determination of absorbed dose in tissue equivalent plastic, an alternative technique for the determination of this quantity, the Fricke Ferrous Sulfate Dosimeter, has been utilized. A G value of 15.5 molecules/100 ev was employed. A small teflon container was constructed, with the same dimensions as the plastic absorbing volume of the calorimeter. This was inserted in a polystyrene absorbing cylinder with dimensions equivalent to those of the calorimeter. The locally absorbed dose determined chemically and calorimetrically agreed to within 1.5 per cent. The local absorbed dose calorimeter is physically direct and experimentally precise. It permits the measurement of the locally absorbed energy with a technique which avoids some of the problems encountered in the use of cavity ionization measurements for this purpose. (auth)

14922 A/CONF.15/P/746

Columbia Univ., New York. Radiological Research Lab. ANALYSIS OF ABSORBED DOSE DELIVERED BY MONOENERGETIC NEUTRONS. Harald H. Rossi and Walter Rosenzweig. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The biological effect induced by a given absorbed dose of ionizing radiation depends, among other factors, on the linear energy transfer (LET) of the particles delivering this dose. Consequently, differences in biological effectiveness exist not only between diverse types of radiation (such as x-rays and neutrons) but within the same type, if the energy is changed markedly. A logical analysis of a radiation field for purposes of radiobiology and radiation protection requires therefore not a separation according to type but rather one according to LET, regardless of type. The LET spectrum of dose usually can not be evaluated theoretically because the type and energy of radiations are frequently not well enough known. In addition, even if the required information can be obtained, theoretical treatments, as presently available, neglect the effects of statistical fluctuations in energy loss which can result in appreciable distortions. An experimental method is reported in which a spherical proportional counter constructed of tissue equivalent solid and filled with tissue equivalent gas may be utilized to determine the mode in which the absorbed dose is delivered to small individual spheres of soft tissue. The pulse height distribution produced by this device represents an event spectrum showing the absolute number and size of energy events making up the total absorbed dose. A simple evaluation of these data yields the fraction of the total energy absorbed that is delivered by ionizing particles depositing a given amount of energy. A further mathematical analysis yields the LET spectrum of dose in those instances where this concept has a reasonably precise meaning. The work to be presented represents a systematic study of the above three curves for neutron energies between 0.1 and 14 Mev for spheres of soft tissue ranging in diameter from $\frac{1}{2}$ μ to 10 μ. As will be shown, practical application of this instrument in conjunction with the tissue equivalent ionization chamber yields a high degree of differentiation between absorbed doses delivered by simultaneous application of neutron and gamma radiation and a complete evaluation for purposes of personnel protection of radiation fields of unknown composition. As an illustration preliminary health survey data obtained at a 3 Bev proton accelerator will be shown. (auth)

14923 A/CONF.15/P/747
Airborne Instruments Lab., Inc., Mineola, N. Y.
AUTOMATIC ANALYSIS OF TRACKS IN NUCLEAR EMULSIONS. K. C. Speh. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Photographic emulsions excel other nuclear detectors and dosimeters in their reliability, small size, zero dead-time, and capacity for storing the details of rapid nuclear processes. Their chief disadvantage is the slow and tedious analysis required for the evaluation of microscopic tracks. Since the first Geneva Conference several novel instruments have been developed to scan emulsions automatically and give a rapid count of tracks. This paper will review the design and performance of these instruments and discuss the prospects of increasing their capacity to analyze more complex problems than track counting. (auth)

14924 A/CONF.15/P/761
Mellon Inst. Radiation Research Labs., Pittsburgh.
ABSOLUTE DOSIMETRY OF IRRADIATIONS WITH CHARGED PARTICLES. Robert H. Schuler. 17p.

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A detailed discussion is given of the manner in which absolute dosage measurements can be carried out with various sources of charged particle radiations. The discussion includes considerations of the use of fast electron beams from an electrostatic accelerator, proton, deuteron and helium ion beams from a cyclotron, and charged particle radiations produced by activation of boron and lithium solutions with neutrons. In each case it is possible to determine the number and energy of particles to which the sample was exposed so that the total energy absorbed is known to a few percent or better. In the case of fast electron experiments, for example, the radiation-chemical yield for ferrous oxidation in the Fricke dosimeter was calibrated, on an absolute scale, to better than one %. With the techniques now available it is possible to conduct detailed investigations of the effect of regions of high local energy deposition on chemical and biological reactions. Such studies were carried out on a number of aqueous systems and are described. From these a quantitative picture is derived for the chemical reactions taking place near the track of the ionizing particle where radicals are present at very high concentrations. Similar but somewhat more preliminary work was also carried out on a number of organic materials. The radiation-chemical yield for systems irradiated with particles of high linear energy transfer are of value in the consideration of these systems as possible dosimeters for fast neutron experiments. (auth)

14925 A/CONF.15/P/762
Argonne National Lab., Lemont, Ill.
LOW INTENSITY SPECTROMETRY OF THE GAMMA RADIATION EMITTED BY HUMAN BEINGS. C. E. Miller. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

As a consequence of the widespread use of radioelements in medical and industrial research, and of the prospective reliance on nuclear fission for the generation of useful power, the probability of contaminating the human body with radioactive materials is bound to increase. Since this contamination must be kept within limits consistent with the safety and welfare of the individual, it is obvious that procedures capable of measuring radioactivity in the human body below these levels will be a substantial help in many fields. In many instances, this situation can be aided materially by means of low level gamma ray measuring techniques, which permit the evaluation of very low specific activities of many radioelements in specimen of relatively large bulk. The development of gamma ray spectrometry at low levels of intensity resulted in the attainment of both the sensitivity and selectivity necessary to various tasks. To eliminate the interference of the natural radioactivity in the immediate surroundings, measurements are made within a $2 \times 2 \times 2$ meter enclosure with walls of laminated sheets of steel, 20 cm in thickness. NaI(Tl) crystals are used for gamma ray detection because of their superior spectrometric properties. Whole-body levels are measured by a 8" × 4" thick crystal, placing the subject on an arc of a circle or the standard reclining chair. Collimated crystals of various sizes are used to scan the individual and determine the distribution of activity. Under favorable circumstances localized activities as low as 2×10^{-10}c have been measured with reasonable accuracy. It is impossible to adequately cover within the limits of an abstract both the uses to which this instrument has been put or discuss its possibilities in medical investigation. Some illustrative examples, however, are in order. As to the field of industrial hygiene and medicine, it has been possible to study contamination in living humans that has accrued as a result of accidents in the laboratory; valuable data have been obtained on transit time of radioactivity in the lung following inhalation intakes of $RaSO_4$, Pa^{233}, and Te^{129} Contamination due to punctures of contaminants of Am^{241} and Th^{227} has also been followed for a long time and yielded, in the latter case, information on equilibrium of the radioactive chain in vivo. It is obvious that these techniques will allow systematic studies of metabolism by multiple tracer techniques and that they are particularly well adapted to long term investigations using fairly long lived isotopes, since the radioactive burdens required are essentially similar to those encountered at natural levels; a case in point has been the study of Sr^{85} retention (65 days half life) for a period of 18 months following an initial ingestion of only 50 μc. Another merit of this technique in the field of clinical medicine is the accurate determination of total-body potassium by the radioactivity of its isotope K^{40}, devoid of the interfering activity of Cs^{137} which has been shown to vary with both the geographical location and the dietary habits of the individual under investigation. (auth)

14926 A/CONF.15/P/827
Illinois Inst. of Tech., Chicago. Armour Research Foundation.
MEASUREMENT AND CONTROL METHODS USING RADIATION. L. Reiffel. 28p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

New developments described include the following: an analytical instrument for chemical analysis of beryllium in the microgram range; critical x-ray absorptiometry; methods for rapid non-destructive thickness control for photographic film emulsions; and an x-ray fluorescence method using beta rays from a long lived emitter to produce x rays in a target which are then used for measuring contaminants in industrial environments. Also included are precision radiation absorption methods for automatic determination of the relative concentrations of the elements in 3 or 4 component systems of light elements, and a neutron activation technique for silver plating control. (J.R.D.)

14927 A/CONF.15/P/1762
Geological Survey, Denver.
THE RADIOLUXOGRAPH, A FAST, SIMPLE TYPE OF AUTORADIOGRAPH. J. Ray Dooley, Jr. 7p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

This method is a quick, inexpensive, and simple means to identify uranium- and thorium-bearing minerals when their localization and dissemination in a specimen is questioned or unknown. As a general rule of thumb, a radioluxograph can be made in less than 24 hours of any hand specimen containing uranium or thorium minerals of sufficient concentration to be detected by the ordinary commercial Geiger or scintillation counters commonly used in field exploration. Because of the speed of this technique the method can be used to identify material quickly for further nuclear emulsion studies. (auth)

14928 A/CONF.15/P/1794
Atomic Energy Commission, Washington, D. C.
RECENT DEVELOPMENTS IN INDUSTRIAL APPLICATIONS OF ISOTOPES: GAGING AND NON-DESTRUCTIVE TESTING. Paul C. Aebersold and E. Eugene Fowler. 21p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Radioisotope techniques are being applied to wear studies, process control, and research and development activities in all major industrial fields. However, these users represent less than 10% of the industry that could realize substantial benefits through the use of radioisotopes. (J.R.D.)

14929 A/CONF.15/P/1859
Naval Research Lab., Washington, D. C.
SOLID STATE DOSIMETERS FOR RADIATION MEASUREMENT. James H. Schulman. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Exposure to ionizing radiation can produce changes in a number of the physical properties of insulating solids. Changes in optical properties—specifically in absorption and luminescence—are especially striking with some materials, and these effects have been extensively investigated for application to dosimetry. Resulting from these investigations are dosimetric devices characterized by great convenience in handling, long and perhaps unlimited shelf life, small volume, and ruggedness. The dose range that can be measured by solid state detectors is literally enormous, extending from the order of milliroentgens to beyond 10^8 roentgens, depending upon the phenomenon employed. All solid state dosimeters are secondary instruments and must be calibrated against some standard, such as an ion chamber. Because of the definition of the roentgen solid state dosimeters exhibit an energy-dependent response, particularly at low energies. This is especially serious with inorganic solids because of the comparatively high atomic numbers of their constituents. Selective shielding of these devices has been successfully employed in order to achieve a reasonable energy independence. The general theory underlying inorganic solid detectors may be summarized as follows. When an electron is freed from an atom by irradiation of a solid, it may wander through the material until it is trapped by some constituent, such as a chemical impurity, or by some region of the solid containing a flaw or defect in the structure. The entity or center formed by combination of the electron with the trapping site has different optical properties from the normal solid, i.e., it may absorb light in a spectral region where the normal solid is transparent (coloration), it may emit fluorescent light under conditions where the normal solid would not do so (radiophotoluminescence, thermoluminescence, or stimulable luminescence), or it may fail to fluoresce under conditions where the normal solid would emit light (degradation or quenching of luminescence). These radiation-induced changes are detected by optical techniques and constitute a measure of the dose. The centers are responsible for coloration, radiophoto-luminescence, or the degradation of luminescence are generally quite stable, permitting repeated measurement of the dose if desired. The centers giving rise to thermoluminescence or stimulated luminescence are necessarily destroyed by the measurement procedure, so that the dose reading cannot generally be repeated. Dosimeters based upon all the above mentioned effects are described, their operational advantages and limitations are delineated, and their applications are discussed in personal monitoring, internal dosimetry, and in the radiation-preservation of foods. (auth)

14930 A/CONF.15/P/1882
California. Univ., Berkeley. Radiation Lab., and Brookhaven National Lab., Upton, N. Y.
SAFETY PROBLEMS ASSOCIATED WITH HIGH-ENERGY MACHINES. R. Wallace, J. S. Handloser, B. J. Moyer, H. W. Patterson, L. Phillips, and A. R. Smith. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Complex radiation fields exist around large accelerators. Refinements of older methods and new techniques developed for radiation surveys are described. Among the Berkeley detectors discussed are large plastic scintillators; parallel-plate pulse ionization chambers using Bi^{209}, Th^{232}, U^{235}, and U^{238}; proportional counters lined with Bi^{209} and U^{238}; and In foils inside paraffin spheres both contained within Cd boxes. Experimental measurements of relative biological effectiveness with a cloud chamber and with a proportional counter at Brookhaven are discussed. (M.H.R.)

14931 A/CONF.15/P/1927
Argonne National Lab., Lemont, Ill.; National Bureau of Standards, Washington, D. C.; Naval Research Lab., Washington, D. C.; and Stanford Research Inst., Menlo Park, Calif.
MEASUREMENT SYSTEMS FOR HIGH LEVEL DOSIMETRY. E. J. Hart, H. W. Koch, B. Petree, J. H. Schulman, S. I. Taimuty, and H. O. Wyckoff. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A variety of dosimetric problems are involved in the investigation and practical utilization of gamma-ray and electron-beam doses of high levels. The dose levels considered in this report are 10^4 to 10^7 rads. Within this range, the response of the dosimetric device should be independent of dose rate, independent of the radiation energy, and independent of temperature over a considerable interval above and below room temperature. Other necessary or desirable features include: a high degree of reproducibility; stability of the dose indication with time; simplicity of preparation, maintenance, and use; small volume; long shelf life; and low cost. The relative importance of these requirements and the accuracy demanded will depend also on the precise use of the device as a primary standard, a secondary working

standard, a production monitor device, or as a simple "go-no-go" indicator. The principles of calorimetric, ionization, chemical, and solid state dosimeters are outlined and the advantages and limitations of each method are summarized. (auth)

14932 A/CONF.15/P/2001

Battelle Memorial Inst., Columbus, Ohio.

RECENT RESEARCH IN HIGH-LEVEL GAMMA DOSIMETRY. J. F. Kircher, B. W. King, M. J. Oestmann, Paul Schall, and G. D. Calkins. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Many radiation chemistry and radiation-effects studies are conducted at radiation doses 100-fold or more higher than the maximum dose which can be measured with existing dosimetry systems. When radiation sources for which the intensity varies in an unpredictable manner are used, the determination of total dose by periodic measurement of dose rate is a tedious and, often, inaccurate method. Dose measurements would be greatly simplified if a dosimeter capable of measuring integrated doses in the range 10^6 to 10^9 rads or higher were available. This paper deals with a study of systems which appear promising for use in this high-dose range. Among the types of radiation-induced processes studied for high-level dosimetry are color changes in dyes, depolymerization of polymeric materials, coloration of glasses, and evolution of hydrogen from organic materials. On the basis of information available in the literature several dyes which appeared to be promising for high-level dosimetry were selected for investigation. The best results were obtained with methyl yellow which exhibits a linear and reproducible optical density change as a function of radiation dose up to a dose of about 1×10^8 rads. The extent of radiation-induced degradation of polymers was determined by viscosity changes of solutions prepared from the irradiated materials. Maximum doses which can be measured with several polymers are about 5×10^6 rads with polyisobutylene, 2×10^7 rads with Lucite, and 1×10^8 rads with Parapol S-50, a copolymer of styrene and isobutylene. Several glass systems were studied by measuring optical density as a function of radiation dose. The two most promising glasses studied are Corning, Code 8892 and a special high-antimony glass. The maximum doses which can be measured with these glasses has not yet been determined. However, exposures up to 3×10^8 rads have indicated a linear change in optical density as a function of dose. The radiation-induced coloration has shown no evidence of saturation at the highest doses studied. The possibility of utilizing the hydrogen evolved from an organic material as a means of measuring radiation dose was investigated. Various organic materials were irradiated in contact with metal oxide films. The hydrogen formed is available for partial reduction of the metal oxide. The extent of reduction is reflected by changes in the electrical resistance of the film. Only a few of the numerous possible combinations of organic and metal oxides materials have been studied. A tin oxide-paraffin system has given best results to date. This system has been irradiated to doses of more than 1×10^8 rad. The electrical resistance of the tin oxide decreased as a function of radiation dose and no evidence of saturation was observed at the highest doses used. (auth)

14933 A/CONF.15/P/2009

Kansas. Univ., Lawrence.

RADIATION POLYMERIZATION DOSIMETRY. Frank E. Hoecker, Darrell Q. Brown, and Joon Taik Han. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Quantitative studies of the high energy radiation photo sensitivity of certain liquid monomer-polymers have indicated a possible solution to the problem of high level dosimetry. Investigations of the relation between absorbed dose and factors which influence sensitivity have led to the development of a dependable system of radiation polymerization dosimetry. Changes in the composition of the liquid permit preparation of dosimeters which cover an x ray, gamma-ray dose range from 7.5×10^4 to 10^7 rads. Pre-irradication permits increase of sensitivity which is predictable when radical decay with time is taken into account. Experimental data are obtained by the use of dosimeter cells each consisting of a No. 000 gelatin capsule containing approximately one ml of dosimetric liquid, an air bubble and a 3 mm diameter lead sphere. Gel phase polymerization, a sudden transition from liquid to gel which occurs within a dose increment of 5% of the total dose, is taken as the end-point index and is indicated by the movement of the sphere to the boundary between gel and liquid upon inversion of the cell after irradication. Exposure of the cell to isotropic radiation results in uniform polymerization and failure of the sphere to move after exposure to the design dose. Exposure of the cell with its axis vertical and parallel to the intensity gradient in directional beams of x- or gamma-rays or high energy electrons yields quantitative data when the axial extent of gelation in m.m. in calibrated in terms of delivered dose. Most of the studies use a styrene-polyester as the dosimetric liquid in which radiation absorption produces radicals eventuating in long chain and cross-linked macromolecules. Radiation sensitivity depends upon the composition which may be varied in a number of ways. Elemental iodine used as an inhibitor to reduce the sensitivity, acts as a radical scavenger to give a linear relation between dose and iodine concentration which yields a G value of approximately 7. The sensitivity of the basic dosimetric liquid remains stable for several months after a 5.5% increase in sensitivity during the first four days after preparation. Self termination of the cross-linkage and chain formation is insured by a process interpreted as radical decay revealed by fractionation of exposure with increasing time between fractions. The data lead to an approximately exponential decay curve but the effect appears to be complex possibly due to competition between chain formation and degradation with different time constants. Sensitivity dependence on dose rate does not appear significant between 10^2 rads/min and 10^5 rads/min for x rays and for gamma rays from spent fuel elements. A factor of approximately 2 between doses required for 250 kv x rays at 5000 rads/min and 2 Mev electrons at 10^6 rads/min may be due to lower values of linear energy transfer for the high energy electrons although dose rate dependence clearly appears at 10^7 rads/min for electrons. Evaluation of radiation polymerization as a dosimetric system involves the consideration that it is based on physico-chemical processes similar to those which occur in food preservation and drug product sterilization by radiation. It suggests the possibility of radiation measurement by processes similar to those it is intended to monitor. The dosimeter is small in size, expendable, self contained and readable without auxiliary equipment by untrained personnel. (auth)

14934 A/CONF.15/P/2014

Stanford Research Inst., Menlo Park, Calif.

HIGH LEVEL DOSIMETRY OF GAMMA AND ELECTRON BEAM SOURCES. S. I. Taimuty, R. A. Glass,

and B. S. Deaver, Jr. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

High-level integrating dosimeters for use with gamma and electron beam sources must provide convenient accurate and reproducible measurements of absorbed doses greater than 10^4 rads in a large variety of irradiated systems. A large number of integrating, non-absolute, high-level dosimeters have been proposed, the most prominent of which involve changes in the chemical, colorimetric or luminescent properties of gases, liquids, and solids. However, no one method is capable of meeting all of the requirements. As a first step toward standardization of high-level dosimetry measurements, a review is presented of the present status of the field, the desirable requirements for high-level dosimeters are discussed, and the degree to which various dosimeters meet these requirements under various conditions of use are evaluated. The evaluation is based on information gained in an experimental study of a large number of dosimetry systems which has been conducted in this laboratory. This information is supplemented by a critical review of published data. Another important aspect of standardization is the method used for calibration of non-absolute dosimeters such as those mentioned above. Ionization and calorimetric methods can be used for both gamma radiation and electrons. Combined measurements of particle energy and number of particles absorbed can be used for electrons under the proper conditions. The accuracy, precision, and limitations of these methods for calibration or standardization use under various conditions of radiation type, energy, and dose rate are evaluated. (auth)

14935 A/CONF.15/P/2377

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

GAMMA-RAY SPECTROMETRIC SYSTEMS OF ANALYSIS. R. W. Perkins. 37p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Two gamma spectrometric systems of analysis for the quantitative measurement of complex radioisotope mixtures are described, neither of which require chemical separations. The first system of analysis is for the measurement of eleven radioisotopes in reactor effluent water. The second describes a procedure for the measurement of "fall-out" radioisotopes on vegetation. These procedures provide rapid, sensitive measurements of the small amounts of radioisotopes released to the environs from fall-out. The two basic instruments used in this study were a multichannel NaI(Tl) scintillation spectrometer and a NaI(Tl) coincidence spectrometer. (W.D.M.)

Mesons

14936 A/CONF.15/P/732

California. Univ., Berkeley. Radiation Lab.

PHOTOMESON EXPERIMENTS AT THE BERKELEY 340-MEV SYNCHROTRON. Victor-Perez-Mendes, William Imhof, Robert W. Kenney, Edward A. Knapp, and Walter A. Perkins. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The recent experimental work on photomeson production from hydrogen and deuterium has concentrated on experiments designed to test the accuracy of the Chew-Low theory. Two experiments were performed: (a) measurement of the differential cross section for photoproduction of positive pions by 260-Mev photons on hydrogen at angles from 0 to 160°, and (b) the relative yield of positive pions from deuterium and hydrogen measured at angles from 20 to 60° and meson energies (lab system) ranging from 45 to 140 Mev. For these experiments a liquid hydrogen target with a condenser for liquefying deuterium was used. The positive pions were identified by their characteristic π-μ decay. The main emphasis in these experiments was on small angle measurements. In this angular region the measured differential cross section from hydrogen shows clearly the effect of the direct interaction of the incident photon with the meson current of the nucleon. An analysis of the angular distribution from 0 to 180° of these data and that from the Illinois and California Institutes of Technology experiments by the method suggested by Moravcsik shows that the magnitude of this effect is in good agreement with the theory. In the experiment on the relative yield from D and H, the Chew-Low theory predicts the magnitude of the spin-flip and no-spin-flip interactions. In this case, the magnitude of the effect is largest at small angles. The experimental points are in reasonably good agreement with the numerical results from the work of Uretsky, which is based on the Chew-Low theory and uses a plane-wave approximation corrected for the ^1S neutron-neutron scattering in the final state. (auth)

14937 A/CONF.15/P/734

California Inst. of Tech., Pasadena. Synchrotron Lab.

THE PHOTOPRODUCTION OF MESONS FROM 500 TO 1100 MEV. Matthew Sands. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The total cross section for the interaction $\gamma + p$ for photon energies from 500 to 1000 Mev is about 100×10^{-30} cm^2. Measurements were made with a liquid hydrogen target in the bremsstrahlung beam of an electron synchrotron. The reaction products are listed. The single meson processes show evidence for the existence of a resonance in the interaction near 700 Mev. The photoproduction of K^+ mesons at 1000 Mev occurs with the creation of a Λ particle and has a cross section about $1/_{50}$ that for pion production. (W.D.M.)

14938 A/CONF.15/P/737

Columbia Univ., New York and Brookhaven National Lab., Upton, N. Y.

THE PRODUCTION AND PROPERTIES OF STRANGE PARTICLES AND PIONS AT THE BROOKHAVEN COSMOTRON. R. Serber. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Measurements carried out to investigate the production and properties of strange particles and pions from the interaction of positive and negative pions and protons with protons are summarized briefly. Some conclusions from these measurements are mentioned. A bibliography of Cosmotron publications is included. (M.H.R.)

Meteorology

14939 A/CONF.15/P/426

Weather Bureau, Washington, D. C.

A METEOROLOGICAL STUDY OF POTENTIAL ATMOSPHERIC CONTAMINATION FROM MULTIPLE NUCLEAR SITES. D. H. Pack and C. R. Hosler. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The atmospheric dilution from a number of points within an area is estimated during a stagnant situation using a relatively simple meteorological model. The volume of the atmosphere occupied by the pollutant is computed for periods of 24, 48, 72, and 96 hours and the patterns described. The total movement of air was computed from meteorological data and the zones of interaction between various locations are shown and relative concentrations indicated. It has been suggested that individual fuel processing facilities for each nuclear reactor might be economic and desirable. Utilizing this assumption and available information on fission product releases, amounts of radioactivity resulting from such a fuel processing complex are used as source strengths in the above meteorological conditions. Resulting concentrations as a function of time and distance are indicated. Data are presented to indicate the probability of recurrence of similar or more stagnant meteorological situations in this part of the United States with suggestions of how a similar analyses can be made in other parts of the world. The significance of the extreme weather conditions, favorable for slow dilution of atmosphere pollution is discussed in relationship to the spacing of fuel processing plants and gaseous waste disposal of fission products. (auth)

14940 A/CONF.15/P/1867
Weather Bureau, Washington, D. C.
GLOBAL SCALE DISPERSION BY THE ATMOSPHERE. Lester Machta. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The decrease of concentration downwind of a pollutant source is at its greatest on a global scale. It might be concluded that safety at a distance of say 50 miles always implies safety on a larger scale. However, there are at least two exceptions which make the use of a large scale diffusion theory to reactor effluents worth studying. First, the superposition of effluents from many sources may raise the contamination level over a broad area and second, removal of particulate contamination by rainfall can occur far removed from the source. Atmospheric diffusion theory on a global scale is in only the most primitive state. The use of Fickian diffusion, in which the transport of a property is proportional to its gradient, has been proven to be inadequate in small scale atmospheric problems. Since the statistical theory of turbulence indicates that the concept of Fick's Law is valid at very large scale, i.e., when largest eddies act as diffusing agents, it is possible that the theory is better than might otherwise be expected. A spherical earth requires the use of slightly more sophisticated mathematics than a flat earth but models involving line or band and instantaneous or continuous sources for a sphere are readily treated. The line or band is parallel to a circle of latitude on the assumption that west-east transport, because of the prevailing west-east winds, occurs much more quickly than north-south diffusion. The model can also incorporate radioactive decay without difficulty but deposition by precipitation scavenging is treated only approximately. The most useful model is that of an exponentially increasing band source centered around the industrial belt in North America, Europe and Asia. Once the transient growth of less than a year is over, theory indicates that air concentration and deposited radioactivity everywhere on earth will grow at an exponential rate. Only the emission of short half-life substances can prevent this exponential growth. Some illustrations based on both assumed meteorological parameters such as the rate of lateral mixing and rain scavenging efficiency and using a unit release rate of fission products are offered to show the longitudinal profiles of ground concentration and cumulative deposition. (auth)

14941 A/CONF.15/P/2288
Atomic Energy Commission, Washington, D. C.
PROGRESS IN APPLICATIONS OF METEOROLOGY TO PEACEFUL USES OF ATOMIC ENERGY. J. Z. Holland. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Progress in theoretical and experimental micrometeorology has been accelerated during the last three years, stimulated by the need for quantitative predictions of the levels of radioactivity to be expected in the environment of a nuclear plant. Studies of turbulence spectra have led to the formulation of profoundly simplified laws of atmospheric diffusion, which are supported by more detailed and accurate observations than were available previously. Diffusion over distances of many miles in inversion conditions, which was formerly poorly understood, has been greatly elucidated. Meteorological equations have been combined with climatological statistics to compute various measures of public risk as a function of reactor accident parameters. Automatic methods have been introduced in the operation of environmental observation networks for protection of public health and safety. High-speed computers are being employed increasingly in summarizing and evaluating large numbers of observations. (auth)

Molecular Properties

14942 A/CONF.15/P/1789
Oak Ridge National Lab., Tenn.
THE DISSOCIATION OF DIATOMIC HYDROGEN IONS. C. F. Barnett. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The total cross sections of several gases for dissociation of the diatomic hydrogen ion were measured in the energy range 500 kev to 2.25 Mev. The measurements were made by generating a molecular ion beam in an accelerator, and passing it through a differentially pumped cell containing hydrogen, helium, nitrogen, or argon, at pressures sufficiently low to prevent multiple collisions. The results show that for target gases of hydrogen and helium the cross section can be approximated as varying inversely as the velocity. The measured cross section for hydrogen gas was 4.15×10^{-17} cm^2/gas atom at 500 kev. For heavier gases such as nitrogen and argon the cross sections were found to decrease only 15 to 20% with increasing energy through the energy range under investigation. Preliminary results for energies down to 20 kev were also obtained. For hydrogen gas the cross section reaches a maximum of 5.6×10^{-17} cm^2/gas atom at an ion energy of 140 kev. The cross section for dissociation of the triatomic ion was found to be approximately equal to the cross section of the diatomic ion for an energy of 100 kev. Experiments in which the ion beams were shot through the column of a 300 amp vacuum carbon arc are described. (auth)

Neutrons

14943 A/CONF.15/P/601
Brookhaven National Lab., Upton, N. Y.
SLOWING DOWN AND DIFFUSION LENGTHS OF NEU-

TRONS IN GRAPHITE–BISMUTH SYSTEMS. J. M. Hendrie, J. P. Phelps, G. A. Price, and E. V. Weinstock. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Exponential experiments were performed to measure the slowing down lengths and diffusion lengths of neutrons in graphite-bismuth lattices. The lattices were composed of graphite and bismuth bars, each approximately 1 × 1 × 24 in., with a small amount of aluminum foil, which will eventually be replaced by uranium foils for experiments related to neutron multiplication. The lattice composition varied from all graphite to all bismuth with several intermediate volume ratios. (auth)

14944 A/CONF.15/P/624

General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.

NEUTRON MULTIPLE SCATTERING METHODS. G. W. Stuart. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

One possible method of solving the Boltzmann equation for the neutron distribution function is to decompose that quantity according to the number of scattering collisions which an entering neutron makes within the body. Recent work performed in the U. S. using this neutron multiple scattering approach is reviewed. (W.D.M.)

14945 A/CONF.15/P/627

Knolls Atomic Power Lab., Schenectady, N. Y.

VARIATIONAL SOLUTIONS OF THE TRANSPORT EQUATION. N. C. Francis, J. C. Stewart, L. S. Bohl, and T. J. Krieger. 38p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Several applications of variational principles to transport theory problems of practical interest in reactor theory are presented. The general class of problems treated involves finding the integral, with respect to a prescribed weighting function, of the solution of an inhomogeneous linear integral equation with a symmetrical kernel and prescribed source function. The most extensive results obtained are those in which the scattering and sources are assumed isotropic; however, slab problems with a linear scattering law have also been treated. The modifications necessary when anisotropic sources are present are discussed. A digital computer transport theory code embodying the variational principle is described. The extension of the method to multigroup problems is discussed, and results for the resonance escape probability of a uranium–water lattice are presented. Another energy-dependent problem amenable to variational treatment is the calculation of thermal neutron spectra in infinite media and the evaluation of cross sections averaged over such spectra. (auth)

14946 A/CONF.15/P/631

Knolls Atomic Power Lab., Schenectady, N. Y.

SELF-SHIELDING AND DOPPLER EFFECTS IN THE ABSORPTION OF NEUTRONS. J. C. Stewart and P. F. Zweifel. 45p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A number of methods for treating the effects are reviewed and compared. The first-mentioned problem is treated assuming the neutrons to be monoenergetic. The primary methods discussed treat an isolated absorber embedded in an infinite diffusing medium and include the method of escape probabilities, the method of successive collisions, the Serber-Wilson technique, the Hurwitz-Roe absorption area concept, the P_n and double P_n methods which have been compared in detail by Bengston, and a variational principle based on that of Schwinger which has a wider range of applicability than any of the methods mentioned above, and from which any of those methods can be generated by a proper choice of trail function. Interaction among members of an array of absorbers is also discussed for simple cases, with particular attention to the work of L. S. Bohl for cylindrical arrays. In addition, a scheme for obtaining effective cross sections for use in multigroup calculations, is presented. (auth)

14947 A/CONF.15/P/634

Georgia Inst. of Tech., Atlanta. and Babcock and Wilcox Co. Atomic Energy Div., Lynchburg, Va.

HIGHER ORDER DIFFERENCES IN THE NUMERICAL SOLUTION OF TWO-DIMENSIONAL NEUTRON DIFFUSION EQUATIONS. J. A. Nohel and W. P. Timlake. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A method for reducing the number of operations in solving two-dimensional neutron diffusion equations is presented. The difference equations are derived using 9 points rather than the usual 5. This reduces the truncation error and allows larger mesh intervals with a consequent reduction in the number of simultaneous linear equations to be solved. Finally, a direct method of solving the resulting system of linear equations is compared with the usual iterative procedures. (auth)

14948 A/CONF.15/P/635

Westinghouse Electric Corp. Bettis Plant, Pittsburgh.

THE AGE OF POLONIUM–BERYLLIUM AND POLONIUM–BORON NEUTRONS IN VARIOUS METAL–WATER MIXTURES—A COMPARISON BETWEEN THEORY AND EXPERIMENT. M. Reier. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The slowing down distribution to indium resonance for a point isotropic source of Po-Be and Po-B neutrons has been measured in aluminum–water, iron–water, and zirconium–water mixtures in various proportions at metal–water ratios of zero, 1:2, 1:1, 2:1, and 3:1 by volume. The second moment of the distribution has been obtained from these measurements and compared with theoretical calculations based on a moment's solution of the transport equation. For the case of Po-Be neutrons, good agreement has been obtained for pure water and iron–water and aluminum–water mixtures. The strong effect on the age of inelastic scattering in iron is particularly apparent. The measured ages for zirconium–water mixtures were 10 to 15% higher than the calculations. This disparity is not surprising in view of the uncertainties in the zirconium cross sections used in the calculations. For Po-B neutrons, which have a spectrum more nearly similar to a fission source than Po-Be neutrons, there is a systematic difference between theory and experiment. The calculated age was lower than the measured values. This is consistent with the discrepancy which exists when a similar comparison is made for fission neutrons. The effect on the age of varying the Po-Be and Po-B source spectrum and cross sections used in the calculations are discussed. (auth)

14949 A/CONF.15/P/671

Oak Ridge National Lab., Tenn.

NEUTRON ABSORPTION AT INTERMEDIATE ENERGIES. R. L. Macklin. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Using Sb–Be photoneutron sources (~25 ev), activation cross sections for about fifty nuclides were remeasured and compared with that of iodine. Comparisons with recent fission product poisoning calculations show an average underestimation by a factor of three. The thick spherical shell transmission method was adapted to absorption measurements using flat response neutron detectors. In addition to measuring Sb–Be photoneutron cross sections for isotopes producing radioactivity, this method has also been used with V(p,n) neutrons from 5 to 50 kev to measure neutron absorption as a function of energy for the chief fissionable isotopes. (W.D.M.)

14950 A/CONF.15/P/700

Los Alamos Scientific Lab., N. Mex.

PLUTONIUM–BERYLLIUM NEUTRON SOURCES, THEIR FABRICATION AND THEIR YIELD. R. E. Tate and A. S. Coffinberry. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An investigation of the plutonium-beryllium phase diagram demonstrates the suitability of these alloys and most particularly the intermetallic compound $PuBe_{13}$ for stable neutron sources. These sources are superior to polonium–beryllium sources in respect to stability of neutron yield as a function of time and the predictability of neutron yield as a function of mass. The gamma-ray emission of plutonium–beryllium sources is very much less intense than that associated with radium–beryllium sources of corresponding neutron strength. The neutron yield is discussed in terms of the microstructure and in terms of the relative distribution of plutonium isotopes. Properties of the compound $PuBe_{13}$ pertinent to source fabrication and a method for preparing suitable material are described. Designs of cylindrical and spherical containers suitable for magnetic handling are presented. A technique for encapsulating the neutron emitting material and testing the integrity of the resulting source is described in detail. (auth)

14951 A/CONF.15/P/752

National Bureau of Standards, Washington, D. C.

STANDARDS FOR NEUTRON FLUX MEASUREMENT AND NEUTRON DOSIMETRY. R. S. Caswell, J. Chin, and E. R. Mosburg, Jr. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Uses of the different types of standard neutron sources and detectors are discussed. The methods of neutron standardization in use at the National Bureau of Standards are discussed. The recently improved agreement in the absolute measurement of the total emission rates of the standard neutron sources of the countries of the world are reviewed. Suggestions are made for international comparisons of standards of thermal neutron flux and absorbed dose for neutrons. (M.H.R.)

14952 A/CONF.15/P/1540

General Atomic Div., General Dynamics Corp., San Diego, Calif. and Brookhaven National Lab., Upton, N. Y.

NEUTRON THERMALIZATION BY CHEMICALLY BOUND HYDROGEN AND CARBON. A. W. McReynolds, M. S. Nelkin, M. N. Rosenbluth, and W. L. Whittemore. 42p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The effects of interatomic binding on the inelastic scattering of slow neutrons by zirconium hydride, polycrystalline graphite, and water were studied. This investigation consisted of a series of neutron beam experiments at the Brookhaven National Laboratory, their theoretical interpretation, and application to the design of a reactor moderated by ZrH and H_2O. Using a crystal spectrometer to obtain monoenergetic beams from 0.05 to 0.3 ev, three types of measurements have been performed: measurement of total scattering cross section as a function of energy, angular distribution of scattered intensity, and average energy, $\bar{E}$, of scattered neutrons as a function of incident energy, angle, and temperature of scatterer, measured by transmission methods. The same crystal phenomena were studied using either a beryllium-filtered beam of very slow neutrons, or a monoenergetic beam selected by a crystal spectrometer, with a chopper time-of-flight apparatus to measure the energy spectrum of neutrons scattered at 90 degrees. (auth)

14953 A/CONF.15/P/1541

Westinghouse Electric Corp. Bettis Plant, Pittsburgh and Knolls Atomic Power Lab., Schenectady, N. Y.

THE THEORY FOR THE NUMERICAL SOLUTION OF TIME-DEPENDENT AND TIME-INDEPENDENT MULTIGROUP DIFFUSION EQUATIONS. R. S. Varga and M. A. Martino. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Mathematically rigorous foundations are given for the time-dependent and time-independent multigroup approximations, not only for the discrete (space) numerical problem consisting of a finite number of mesh (lattice) points, but for the continuous space problem as well. In so doing, the discrete numerical approximations to the multigroup diffusion equations, as solved on digital machines, are shown to be well-set. (M.H.R.)

14954 A/CONF.15/P/1839

General Atomic Div., General Dynamics Corp., San Diego, Calif. and Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

RECENT WORK IN NEUTRON THERMALIZATION. M. S. Melkin and E. R. Cohen. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experimental results include data on inelastic scattering of slow neutrons by moderating materials, measurements of neutron spectra for close-packed water lattices, and temperature-coefficient measurements on a zirconium hydride-moderated critical assembly. Theoretical work includes the theory of slow-neutron inelastic scattering by zirconium hydride with application to reactor spectrum and temperature-coefficient calculations, a theory of slow-neutron inelastic scattering by water, and calculations of chemical binding effects on the "diffusion cooling" phenomenon. Neutron-spectrum calculations are discussed for a monatomic gaseous moderator of intermediate mass, for a heavy gaseous moderator with a temperature discontinuity, and for a moderator in which the effective molecular mass is varied. (auth)

14955 A/CONF.15/P/1847

Argonne National Lab., Lemont, Ill. and Brookhaven National Lab., Upton, N. Y.

RESONANCE CAPTURE IN URANIUM AND THORIUM LUMPS. B. I. Spinrad, J. Chernick, and N. Corngold. 38p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Theoretical results obtained both by parametric

integral theories and by Monte Carlo methods are presented. A critique of experimental methods in terms of these results is included. Quantitative formulations were derived by which resonance integrals may be computed on a line-by-line basis for mixtures, clusters, and lumps. (M.H.R.)

14956 A/CONF.15/P/1988

General Atomic Div., General Dynamics Corp., San Diego, Calif.

THE QUANTITATIVE EVALUATION OF RESONANCE INTEGRALS. F. T. Adler, G. W. Hinman, and L. W. Nordheim. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A means is provided for a complete and rigorous evaluation of resonance integrals along the lines proposed by Wigner. Calculations for uranium metal and UO_2 rods lead to excellent agreement with the best available experimental data. An extensive set of tables were prepared from which resonance escape probabilities and Doppler temperature coefficients can be obtained with little effort for all temperatures and compositions for a wide variety of geometries. These results encompass, besides metals and oxides, heteogeneous systems in which the absorber region contains moderator as well as Th^{232} or U^{238}. (M.H.R.)

14957 A/CONF.15/P/2375

Nuclear Development Corp. of America, White Plains, N. Y.; Knolls Atomic Power Lab., Schenectady, N. Y.; and General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

THE SLOWING DOWN OF NEUTRONS IN HYDROGENOUS MEDIA—STATUS OF THEORY AND EXPERIMENT. Herbert Goldstein, P. F. Zweifel, and D. G. Foster, Jr. 67p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The developments on the slowing down of neutrons in hydrogenous media since 1955 are reviewed. The paradox is discussed, that while neutron age can be calculated by rigorous methods, the computed values are in consistent disagreement with experiment. The situation for fission neutrons in light water is described first. Then, the experimental evidence and the theoretical calculations are considered for other combinations of source and moderator. Some of the recent calculations of neutron flux curves in hydrogenous media, obtained mainly by the spatial moments and Monte Carlo techniques, are presented. Applications to reactor problems are discussed, treating particularly machine codes involving the Fourier transform method and the use of rigorous point kernels in reactor calculations. (M.H.R.)

14958 A/CONF.15/P/2494

California. Univ., Livermore. Radiation Lab.

FAST NEUTRON CROSS SECTIONS. Jacob Beneniste. 24p. (UCRL-5220). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A large, cadmium-loaded liquid scintillator has been employed for the measurement of (n,2n) cross sections at 14 Mev. Results on a series of elements ranging from beryllium to bismuth show that at several Mev above the (n,2n) threshold the nonelastic cross section is essentially all due to the (n,2n) process. Time-of-flight techniques have been applied for the observation of gamma-ray spectra resulting from 14-Mev neutron interactions with a number of elements. Typically, line spectra appear superposed on continua extending out as far as about 10 Mev. The lines can be identified in terms of transitions between known levels of the residual nuclei. Cross section measurements indicate the manner in which the electromagnetic de-excitation takes place. (auth)

Nuclear Physics

14959 A/CONF.15/P/651

California. Univ., Berkeley. Radiation Lab.

DEFORMATION ENERGY OF A CHARGED DROP. III. FURTHER DEVELOPMENTS. Wladyslaw J. Swiatecki. 72p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Certain asymmetric configurations of a charged drop are discussed qualitatively, and this serves to bring out certain similarities between fission on the one hand and the emission of smaller fragments, or the reverse process of the bombardment of nuclei with heavy ions on the other. The existence of a hitherto unexplored asymmetric shape of unstable equilibrium is suggested on qualitative grounds. The deformation energy of a charged drop is calculated by further extensions of expansions about spherical and spheroidal shapes. In the former case, general recurrence relations are derived, making possible the calculation of the surface and electrostatic energies of an axially symmetric drop to any order in the coefficients α_n of the Legendre polynomials specifying the distortion, and for all values of n. An error in Nossoff's fourth-order formula is rectified, and an expansion up to the sixth order in the most important coefficients is given explicitly for a distortion specified by α_1, α_2, α_3, α_4, α_5, α_6, and α_7. This formula is used to derive an expansion to sixth order in $(1-x)$ for the threshold energy of the conventional saddle-point shapes. Down to $x \sim 0.6$, the results agree to about 1% with earlier calculations based on expansions about spheroids. The expansions about spheroidal shapes are themselves extended and are used in particular to study the "stiffness" of the saddle-point shapes against various types of distortions. The stability of the symmetric saddle-point shapes against asymmetric distortions is also investigated. (auth)

14960 A/CONF.15/P/693

Argonne National Lab., Lemont, Ill.

AN EFFECT OF SHELL STRUCTURE IN THE LEVEL DENSITY OF HIGHLY EXCITED NUCLEI. N. Rosenzweig, L. M. Bollinger, L. L. Lee, Jr., and J. P. Schiffer. 24p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A review of the existing experimental data on nuclear level density, a summary of the theoretical analysis carried out during the last three years, a critical discussion of the effects produced by shell structure, and a discussion of the possibilities of more detailed inferences about nuclear structure in the light of the most recent theoretical and experimental advances are contained in this paper. (W.D.M.)

14961 A/CONF.15/P/1026

Los Alamos Scientific Lab., N. Mex.

THE FREE ANTINEUTRINO ABSORPTION CROSS SECTION. PART I. MEASUREMENT OF THE FREE ANTINEUTRINO ABSORPTION CROSS SECTION. F. Reines and C. L. Cowan, Jr. PART II. EXPECTED CROSS SECTION FROM MEASUREMENTS OF FISSION

FRAGMENT ELECTRON SPECTRUM. R. E. Carter, F. Reines, J. J. Wagner, and M. E. Wyman. 38p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Part I. The cross section for the reaction, $\nu_- + p \rightarrow \beta^+ + n$, was measured using reactor antineutrinos (ν_-). Target protons were provided by a 370 gallon liquid scintillation detector in which the scintillator solution (triethylbenzene, terphenyl, and POPOP) was loaded with a cadmium compound (cadmium octoate) to allow the detection of the reaction by means of the delayed coincidence technique. The first pulse of the pair was caused by the slowing down and annihilation of the positron (β^+) the second by the capture of the neutron (n) in cadmium following its moderation by the scintillator protons. A second scintillation detector without cadmium loading was used above the first to provide an anticoincidence signal against cosmic ray induced events. The antineutrino signal was related to the reactor by means of runs taken while the reactor was on and off. Reactor radiations other than antineutrinos were ruled out as the cause of the signal by a differential shielding experiment. The signal rate was 44 events/hour and the signal to noise was $1/8$, where half the noise was correlated and cosmic ray associated and about half was due to non-reactor associated accidental coincidences. The cross section per fission ν_- (assuming 6.1 ν_- per fission) for the inverse beta decay of the proton was measured to be $4 \pm 1 \times 10^{-44}$ cm^2. Part II. The cross section expected for the reaction $\nu_- + p \rightarrow \beta^+ + n$ using ν_- from fission fragments is a function of the ν_- spectrum as well as the particular neutrino theory employed. The cross section for the two component theory is a factor of two greater than that predicted by the four-component neutrino theory. In an attempt to test neutrino theories, experiments are being performed to enable the inference of the antineutrino spectrum from the fission fragments via a measurement of the electron spectrum from these fragments. In these experiments a foil of U^{235} is irradiated by thermal neutrons, and the emitted electron spectrum is studied by means of small plastic scintillators placed in a collimator shield set off to one side of the neutron beam. Backgrounds due to gamma rays reduced to less than $1/10$ the electron signal by means of a transmission proportional counter placed in front of the scintillation detector. Details and results of these experiments are reported. (auth)

14962 A/CONF.15/P/1427

Stanford Univ., Calif.

STRUCTURE IN THE PROTON AND THE NEUTRON. Robert Hofstadter. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A survey of the recent work on the structures of the proton and the neutron carried out by high-energy electron-scattering methods is presented. Early work established finite size effects in the proton and led to information about the charge and magnetic density distributions in the proton. The rms size was established to be close to $(0.77 \pm 0.10) \times 10^{-13}$ cm, and the density distributions of charge and anomalous magnetic moment were shown to be approximately of the same shape. The form factors could be described in terms of several alternative models given, for example, by an exponential, gaussian, hollow exponential, hollow gaussian, etc., distribution of densities. Many other shapes were excluded by the experimental data. Recent work by Bumiller and Hofstadter now fixes one among these models that is appropriate to the proton and provides an extremely good fit at all angles between energies of 200 and 650 Mev. The new evidence clearly favors the exponential model with rms radius $(0.80 \pm 0.04) \times 10^{-13}$ cm. Recent studies of the proton have attempted to answer the question: how closely similar are the charge and magnetic form factors? This work now shows that the distributions have the same sizes and shapes to within 10 per cent, and each distribution is given very closely by the exponential model described above with radius $(0.80 \pm 0.04) \times 10^{-13}$. Certain other similar models will be discussed. Early work on the inelastic continuum in the deuteron established that the neutron's magnetic structure was extended and not a point. It was further shown that the neutron's size was approximately the same as that of the proton. This work has recently been extended by Yearian and Hofstadter to a determination of the variation of the neutron's magnetic form factor over the range where the proton's form factor is known. The new results show: (1) the neutron is not a point, (2) the neutron's magnetic structure has a size lying between the limits 0.78×10^{-13} cm and 0.90×10^{-13} cm. The first value (0.78×10^{-13} cm) is determined by examining the total deuteron electrodisintegration cross section at a given angle and incident energy and comparing this cross section with that of the free proton under the same conditions. The second value (0.90×10^{-13} cm) is found by examining the peak of the deuteron electrodisintegration cross section. Because of possible contributions to the total cross section by mesonic exchange effects, the second method is believed to be slightly more accurate. The neutron size is, therefore, approximately $(0.80 \pm 0.10) \times 10^{-13}$ cm. Thus the magnetic clouds of the neutron and proton are closely the same. The bearing of these results on the validity of electrodynamics is discussed. Because of the small radius implied by the neutron-electron experiments, there is an anomaly between the neutron and the proton. This is represented by the small charge radius for the neutron and the much larger radius of the proton. Additional information of the structure of the deuteron and on the production of pions by electrons is also furnished by the same experiments and will be discussed at the meeting. (auth)

14963 A/CONF.15/P/2393

California. Univ., Berkeley. Radiation Lab.

PIONS AND ANTINUCLEONS. Geoffrey F. Chew. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A survey is made of recent experimental and theoretical work in the United States on the strongly coupled "ordinary" particles, particularly pions and antinucleons. The role in this field of dispersion relations is reviewed, and their possible violation in pion-nucleon scattering discussed. Various experimental determinations of the pion-nucleon coupling constant are considered. Experimental results on nucleon-antinucleon scattering and annihilation are summarized and discussed within the framework of different theoretical models. The relationship of nucleon-antinucleon and nucleon-nucleon systems is considered and emphasis is given to the success of the Yukawa hypothesis that the exchange of pions constitutes the main interaction in these systems. Experiments on the interaction with complex nuclei of pions, nucleons, and antinucleons are briefly summarized and discussed in terms of the nuclear optical model. (auth)

14964 A/CONF.15/P/2399
Massachusetts Inst. of Tech., Cambridge.
THE PROPERTIES OF NUCLEAR MATTER. Victor F. Weisskopf. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An explanation is given why nuclear matter exhibits the properties of a system of independent particles in spite of the existence of strong interaction forces. Thus, a theoretical understanding of the shell model is possible, since the latter is based upon the independent motion of nucleons. The cause of the approximately independent motion lies in the peculiar effects of the Pauli-principle. A given pair of particles, when embedded in a degenerate system of many equivalent particles, has a different dynamics of interaction, than an isolated pair. The effect of the nuclear forces upon the motion of the embedded pair is greatly reduced and it is practically nonexistent if the radius of the repulsive core is small compared to the distance d between the particles and if the attractive part of the interaction potential is below a certain critical value $V_{crit} = (3\pi^2/2)^{\frac{2}{3}} (\hbar^2/Md^2)$. It is shown that the degenerate Fermi-gas exhibits a certain stiffness towards interacting forces and retains the dynamical properties of a free particle gas even in the presence of strong forces if they comply with these conditions. The strength of the actual nuclear forces are well below the critical limit. Hence, they are not strong enough to break the stiffness of the nuclear Fermi-gas. The same "weakness" of the nuclear forces is also exhibited in the fact that the deuteron has only one bound state. The case of nuclear matter is compared with the case of atomic matter consisting of Femi particles, as, for example, nitrogen at very low temperatures. (auth)

Nuclear Properties

Refer also to abstracts 15180 and 15181.

14965 A/CONF.15/P/642
Washington. Univ., Seattle.
FISSION ANGULAR DISTRIBUTIONS AND FISSIONABILITY AT MODERATE ENERGIES. I. Halpern and C. T. Coffin. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An account of some measurements of the angular distribution of fission fragments from nuclei excited to several tens of Mev are presented. In order to interpret such measurements it is necessary to know to what extent fission takes place in the compound nuclei originally formed, and to what extent it takes place after the emission of neutrons. For this reason, the experimental evidence relating to fission probabilities at moderate energies is examined in some detail. Some conclusions and speculations suggested by the data are given. (auth)

14966 A/CONF.15/P/650
California. Univ., Berkeley. Radiation Lab. and Indiana. Univ., Bloomington.
BETA RADIOACTIVITY AND ENERGY LEVELS OF HEAVY NUCLEI: DECAY SCHEMES OF Np^{239}, U^{237} AND Np^{238}. J. M. Hollander, J. O. Rasmussen, R. G. Albridge, Jr., and W. G. Smith. 22p. (UCRL-8072). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The isotopes, Np^{239}, U^{237}, Np^{238}, and Pa^{233}, were produced by intensive neutron irradiations in the Materials Testing Reactor. High resolution magnetic electron spectrographs and scintillation gamma-ray spectrometers were used. The energy-level spacings, rotational spectra, general photon transition-probability relationships, and other results are summarized. (M.H.R.)

14967 A/CONF.15/P/662
Los Alamos Scientific Lab., N. Mex.
THE WEISZÄCKER MASS FORMULA AND NUCLEAR SIZES AND FORCES. A. E. S. Green. 18p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Atomic mass data constitute one of the most precise and extensive arrays of experimental information which can be used for the interpretation of nuclear phenomena. These data, when interpreted in the light of current theoretical ideas concerning the structure of the nucleus, can lead to detailed conclusions concerning the energy content of nuclei, the nature of nuclear forces, the sizes of nuclei, and the thickness and densities of the outer layer of the nucleus. An analysis is first made of the most recent experimental mass data in an effort size of the proton distribution, are examined. The Weiszäcker equation has most often been derived using a Fermi gas or liquid drop model of the nucleus. In view of the impressive successes of the shell model of the nucleus and particularly the successes of optical model potentials in the analysis of neutron and proton scattering and neutron and proton binding energies, an effort is made to relate the Weiszäcker equation directly to such potentials. Working with non-local or velocity dependent nuclear potentials as they arise out of the Brueckner-Bethe self consistent field methods, it is shown that one can derive a mass surface fairly directly. The mass surface parameters, particularly the symmetry term, are not satisfactory, however. It is shown that by the addition of a reasonable perturbation which had previously been inferred from lost to arrive at the smooth trends which must be accounted for by a statistical theory such as originally proposed by Weiszäcker. The Bethe-Weiszäcker equation is then reexamined in relationship to these trends. The influence of various corrections to the Bethe-Weiszäcker equation is then considered using a perturbation procedure. It is shown that several of the more obvious theoretical corrections to the Bethe-Weiszäcker mass formula can cause a deterioration of the fit to the nuclear mass. These corrections must be applied in combinations if one is to retain or improve upon the good fit attainable with the simple Bethe-Weiszäcker form. A number of combinations and their implications and consequences, particularly in relationship to the particle binding energy considerations, that one can derive a fairly satisfactory mass surface. One characteristic of this mass surface is the presence of a large surface symmetry term which is negative in magnitude. The implications of the results relative to the size and form factors of the neutron, proton densities and potentials, as well as certain implications relative to the theory of fission, are discussed. (auth)

14968 A/CONF.15/P/663
Los Alamos Scientific Lab., N. Mex.
FISSION CROSS SECTIONS AT MEV EXCITATION. A. Hemmendinger. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Recent experiments on fission are reviewed. Problems associated with the passage of the distorted nu-

cleus over the fission barrier are considered, with particular emphasis on the energy dependence of fission cross sections and angular, mass, energy, and charge distributions. (W.D.M.)

14969 A/CONF.15/P/666
Los Alamos Scientific Lab., N. Mex.
SOME RECENT RESULTS ON FAST NEUTRON CROSS SECTIONS. J. H. Coon, comp. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A summary of recent neutron cross section work by several groups at Los Alamos in the energy range 0.1 to 16 Mev is presented. Calculated and experimental data are presented for the differential elastic scattering cross sections of C, Al, Fe, Cu, Sn, Pb, and U for 14.5-Mev neutrons. Angular distributions of the inelastic neutrons emitted in the interaction of 14-Mev neutrons with several complex nuclei were measured for neutrons in three energy regions: 0.5 to 4 Mev, 4 to 13 Mev, and 9 to 13 Mev. Total cross sections of C, Ca, Ti, Ba, La, Ce, Nd, Sn, Gd, Er, Ta, Au, and Pb for neutrons of energy between 13.1 and 15.6 Mev were measured by the transmission technique with good geometry. By using a pulsed-beam time-of-flight technique, differential elastic and total neutron cross sections for Be were measured at 2.6, 3.5, 4.1, 5.0, and 6.0 Mev to an accuracy of approximately 5%. The angular distribution of tritons from the $Li^6(n,t)He^4$ reaction was measured at neutron energies of 150, 200, 258, 300, 350, and 565 kev. Neutron emission from the reaction $B^{11}(\alpha,n)N^{14}$ was measured in detail in the alpha particle energy range from 2 to 7 Mev. (M.H.R.)

14970 A/CONF.15/P/667
Los Alamos Scientific Lab., N. Mex.
RADIATIVE CAPTURE OF FAST NEUTRONS. B. C. Diven. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A new and universal method for measurement of radiative capture cross sections has been developed. The method is applicable to the measurement of capture cross sections for nearly all nuclides and can be used with neutrons of any energy from the thermal region to a few Mev. Monoenergetic neutrons from 150 kev to 1 Mev have been used to date. A pulsed and collimated neutron beam is passed through the capturing sample at the center of a large liquid scintillator. Capture is detected by counting the capture gamma radiation in the scintillator in coincidence with the pulsed beam. The cross section is determined by comparison with the fission plus capture rate in a sample of U^{235} since the cross sections for these processes are well-known. The samples consist of a large number of thin discs 3.7 cm in diameter and 1 mm or lean in thickness, separated by several millimeters. The resulting sample is reasonably transparent to the capture gamma radiation produced in it. The liquid scintillator is a cylinder approximately 1 meter in diameter and length, with an axial cylindrical opening 7 cm in diameter. The neutron beam passes along the axial tube and through samples. The techniques of this experiment allow one to measure the radiative capture cross section of any substance which is not too radioactive and which can be obtained in quantities of one-tenth mole or more. The accuracy so far achieved is about 10% or 1 millibarn, whichever is larger. The energy range covered is 150 kev to 1 Mev, and preparations are underway to extend the range down to 30 kev. The upper limit on neutron energy arises from the necessity of rejecting those pulses due to slowing down of scattered neutrons and to gamma rays from inelastic scattering. The elements studied to date are Ni, Mo, In, Ta, Au, Cr, Fe, Zr, Nb, U^{235}, U^{238}, Pu^{239}, Cd, and Cu. (auth)

14971 A/CONF.15/P/672
Oak Ridge National Lab., Tenn.
STUDIES OF SHORT-LIVED FISSION PRODUCTS AND THEIR IMPORTANCE TO REACTOR TECHNOLOGY. G. D. O'Kelley, E. Eichler, and N. R. Johnson. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A systematic study of the decay schemes of some of the important alkali metal isotopes was made. Information is available on 17.8-minute Rb^{88}, 14.9-minute Rb^{89}, and 2.6-minute Rb^{90}. The decay characteristics of these nuclides show the general features exhibited by all of the short-lived fission products studied so far, namely, the short half-lives are related to high beta decay energies, which in turn permit the excitation of many nuclear levels at relatively high energies. Consequently, the gamma-ray spectra are very complex. For example, the maximum beta-ray energies in Rb^{88}, Rb^{89}, and Rb^{90} are 5.30, 3.92, and 6.2 Mev, respectively, and the most energetic gamma-rays are 4.87, 3.52, and 5.25 Mev, respectively. The radiations from halogen fission products are also under investigation. Br^{84} (32 minutes) was intensively studied. Besides the well-known beta-ray group at 4.7 Mev, several other high-energy beta groups were characterized. From a shielding point of view it was disquieting to discover a series of intense gamma rays from 0.81 to 3.93 Mev in the Br^{84} decay. Studies on 52-minute I^{134} and 86-second I^{136} have proved interesting, since they excite similar energy levels in Xe^{134} and Xe^{136}. The beta-ray spectrum of I^{134} exhibits an energetic component of 3.5 Mev, and at least 4 components of lower energy. The gamma-ray spectrum of I^{134} extends to 1.78 Mev, but the intense radiations are found in the region of 0.5 to 1.3 Mev, of which the most intense are at 0.84 and 0.89 Mev. The I^{136} decay is similar but the radiations are more energetic. Beta-ray transitions of 7.0 and 5.7 Mev energy are a striking feature of the I^{136} beta spectrum. A pair of gamma rays at 1.32 Mev dominates the I^{136} gamma-ray spectrum, although there are six additional gamma rays to a maximum energy of 3.18 Mev. (auth)

19472 A/CONF.15/P/673
Oak Ridge National Lab., Tenn.
LOW ENERGY NEUTRON CROSS SECTIONS OF RADIOACTIVE FISSION PRODUCT NUCLIDES. J. A. Harvey, R. C. Block, G. G. Slaughter, W. J. Martin, and G. W. Parker. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Data on Sm^{151} and Pm^{147} were obtained, and resonances were assigned. Transmission measurements were also made on fission product samples of Zr and I, but no resonances could definitely be assigned to I^{129} and Zr^{93} in the energy range from 1 to 100 ev. (M.H.R.)

14973 A/CONF.15/P/675
Naval Research Lab., Washington, D. C.
MEASUREMENTS OF THE ENERGIES AND WIDTHS OF CERTAIN NARROW RESONANCES. R. O. Bondelid and C. A. Kennedy. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An electrostatic analyzer with a radius of curvature of 2 meters and a deflection angle of 90° was constructed, installed, and evaluated. It is used in conjunc-

tion with the U. S. Naval Research Laboratory large Van de Graaff to provide a positive ion beam whose energy is precisely known and highly resolved. The absolute energy calibration is believed to be accurate to ±0.05%, and the inherent energy resolution is accurately 0.01% per 0.010 in. of input slit separation. The analyzer was used to determine the bombarding energies of several (p,γ) resonances and (p,n) thresholds in the energy range from 300 kev to slightly over 3 Mev. It has also been used to determine the widths of some very narrow (p,γ) resonances. The results from the absolute determination of bombarding energy are: $Al^{27}(p,\gamma)Si^{28}$, 992.4 ± 0.5 kev; $C^{13}(p,\gamma)N^{14}$, 1747.6 ± 0.9 kev; $Li^{7}(p,n)Be^{7}$, 1881.2 ± 0.9 kev; $C^{13}(p,n)N^{13}$, 3237.2 ± 1.6 kev; $Ni^{58}(p,\gamma)Cu^{59}$, 1424.1 ± 0.7 kev; $Ni^{58}(p,\gamma)\ Cu^{59}$, 1843.7 ± 0.9 kev; $F^{19}(p,\alpha\gamma)O^{16}$, 340.5 ± 0.3 kev; $F^{19}(p,\alpha\gamma)O^{16}$, 483.6 ± 0.3 kev; $F^{19}(p,\alpha\gamma)O^{16}$, 872.4 ± 0.4 kev. The measurements of the widths of narrow (p,γ) resonances are complicated by the Doppler broadening introduced by the thermal motion of the target nuclei. The resonances that have been examined are a narrow resonance in the $Al^{27}(p,\gamma)Si^{28}$ reaction, two in the $Ni^{58}(p,\gamma)Cu^{59}$ reaction, and one in the $C^{13}(p,\gamma)N^{14}$ reaction. Preliminary data on all of these resonances indicate they are of the order of 100 ev full width at half maximum, or less. In addition to the above results, a curious behavior of the mass-2 proton beam was observed. It is found that the mid-points of the thick-target mass-2 yield curves (obtained in (p,γ) reactions) appear at energies lower than those predicted from the mass-1 results. It is thought at the present time that this behavior is related to stopping power in the target. When using very thin targets, of the order of 300 ev thick, the energy discrepancy between the mass-1 and mass-2 proton beam disappears. (auth)

14974 A/CONF.15/P/685
Argonne National Lab., Lemont, Ill.
SLOW NEUTRON CROSS SECTIONS OF Pu^{240}, Pu^{242} AND Am^{243}. R. E. Cotέ, Lowell M. Bollinger, R. F. Barnes, and H. Diamond. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The results on Pu^{240} cover only the resonance structure which could be studied through the Pu^{240} impurity in some samples of Pu^{239} which were used in an exhaustive study of the latter nuclide. The study of Pu^{242} revealed only two resonances between thermal energies and several kv. Resonance parameters were obtained for these at 2.65 ev and 53.6 ev. Comparison of these results and the thermal activation shows that the resonance at 2.65 ev accounts for the measured thermal activation cross section, but the observed resonances do not account for the measured value of the resonance activation integral. The measurement of the total cross section of Am^{243} was done with only 7 mg of the material. Because the sample was so thin, no measure of the off-resonance cross section could be made except in the thermal region. The measurements at thermal energies show the cross section does not vary as 1/v. Eleven transmission dips were observed below 25 ev, all of which appear to be caused by single resonances. Resonance parameters were derived from these dips and values of the average level spacing per spin state and of the strength function have been computed from these parameters. The properties of these nuclides and of other heavy nuclides are compared. (auth)

14975 A/CONF.15/P/687
Argonne National Lab., Lemont, Ill.
THE SLOW NEUTRON CROSS SECTIONS OF Pu^{239}. L. M. Bollinger, R. E. Cotέ, and G. E. Thomas. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An exhaustive series of measurements on Pu^{239} was undertaken. All partial cross sections that are measurable for slow neutrons either have been or are being measured. (auth)

14976 A/CONF.15/P/735
Naval Research Lab., Washington, D. C.
NUCLEAR CROSS SECTIONS FOR THE SCATTERING OF NEUTRONS AND PROTONS. R. Jastrow and I. Harris. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Measurements of nuclear cross sections for neutron and proton scattering make an essential contribution to the understanding of nuclear structure. The data obtained at the Naval Research Laboratory in this field are summarized, and their theoretical interpretation is discussed. Additional calculations at higher energies, which are compared with data obtained in other laboratories are also discussed. The calculations are based on an optical model with rounded profile, and are carried out in WKB approximation for energies greater than 300 Mev and by exact computation of the phase shifts at lower energies. We find that at 300 Mev the model provides a good description of proton scattering and polarization. The comparison with observation determines the nuclear radius within narrow limits, and, moreover, the radius deduced from the 300 Mev analysis also yields good results for the description of scattering at lower energies, in the neighborhood of 7 Mev. Our value for the rms nuclear radius is $(0.9 + 1.13\ A^{1/3}) \times 10^{-13}$ cm, vs. $(1.0 + 1.00\ A^{1/3}) \times 10^{-13}$ cm for the charge distribution radius determined from electron scattering data. (auth)

14977 A/CONF.15/P/1036
Brookhaven National Lab., Upton, N. Y.
SYSTEMATICS OF NEUTRON RESONANCE PARAMETERS. D. J. Hughes and R. L. Zimmerman. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

All the available experimental results on the systematics of neutron resonance parameters are reviewed. Included are measurements made at Brookhaven during the last year in which parameters are obtained with high statistical accuracy from average cross sections. Particular emphasis is placed on the important fissionable nuclides and structural materials. Recent work at Brookhaven concerns the distribution of level spacings within individual nuclides, a matter that is essential to theoretical cross-section extrapolations. Also discussed are the average spacings as functions of atomic weight, spin, and shell structure, the distribution in size of neutron widths and of radiation widths, the "strength functions" or Γ_n^0/D ratio and its relationship to nuclear models, and the effect of finite angular momentum collisions. The relationship of the data to current theory, such as the cloudy crystal ball, is described, as well as examples of the degree to which the calculated cross sections in the kev region agree with experiment. Particular attention is given to the difficulties that arise when the energy is sufficiently high so that finite angular momentum collisions become significant. (auth)

14978 A/CONF.15/P/1072
Oak Ridge National Lab., Tenn.
SOME CROSS-SECTIONS OF HEAVY NUCLIDES IM-

PORTANT TO REACTOR OPERATION. J. Halperin and R. W. Stoughton. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A value of about 1300 b was obtained for the reactor cross section for Th^{233}, confirming the previous Argonne National Laboratory value; also the resonance contribution to the total absorption in a thermal reactor was shown to be about equal to that expected for a 1/v absorber. An effective cross-section of 140 ± 20 b was previously obtained for Pa^{233} for a graphite-moderated and for a light water-moderated reactor; this value along with Canadian work at Chalk River and work at Arco, Idaho, indicate a thermal value of about 100 ± 20 b. A calculation using the known resonance parameters indicated a thermal capture cross-section of not more than about 15 b for U^{234}; however, an experimental redetermination using the pile-oscillator confirmed the previous value of 90 b, indicating the existence of important negative resonances. Good agreement was found between the calculated and observed effective cross-sections of U^{236} and U^{238} for neutrons of the MTR (a light water-moderated Materials Testing Reactor); the values obtained were 34 ± 6 and 24 ± 4 b for U^{236} and U^{238}, respectively. Calculated and experimentally determined effective cross-sections for neutron capture by Pu^{240} in very dilute concentrations were both about 1200 ± 150 b; calculated and experimental thermal values of about 350 b were found. Effective absorption cross-sections of 1500 and 1600 b and capture cross sections of 500 and 500 b for Pu^{239} and Pu^{241}, respectively, were found to be consistent with the plutonium isotopic compositions found in highly irradiated MTR fuel elements; the values for Pu^{239} were in agreement with calculated values. All the above cross-sections are to be compared with a thermal (2200 m/s) and an effective absorption cross section of 685 and 700 b, respectively, for U^{235}. (auth)

14979 A/CONF.15/P/1881

California. Univ., Livermore. Radiation Lab.

NEUTRON CROSS SECTION MEASUREMENTS PERTAINING TO THE OPTICAL MODEL. M. H. MacGregor. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A summary of experimental neutron cross section measurements in the medium-Mev region is presented. Special attention is given to the measurements at UCRL-Livermore, which cover the energy range from 7 to 29 Mev. Measurements at other laboratories are also included as a basis for comparison and to extend the energy range. Discrepancies in cross-section measurements are discussed, so that "best values" for all the cross sections in this region can be deduced. The implications of these cross-section measurements with respect to the knowledge about nuclear structure are summarized by comparing the experimental values with predictions of optical-model calculations. (auth)

Nuclear Reactors

Refer also to abstract 14757.

14980 A/CONF.15/P/410

Westinghouse Electric Corp. Bettis Plant, Pittsburgh.

RADIOACTIVITY LEVELS IN PRESSURIZED WATER REACTOR SYSTEMS. D. M. Wroughton and P. Cohen. 31p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The three principal sources of radioactivity in the pressurized water reactor are discussed; activation of the water and its impurities by the neutron flux, activation of structures exposed to neutrons in the vicinity of the core, and fission products in the fuel. Information collected from plant operation and special tests is given on the radioactivity levels resulting from corrosion products and from fission product release through various modes of failure. Some observations on corrosion product and activity levels in operating systems are presented and, where possible, these levels are related to conditions of operation. (M.H.R.)

14981 A/CONF.15/P/413

General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.

A 10 MEGAWATT RADIATION EFFECTS REACTOR FOR THE IRRADIATION OF LARGE EQUIPMENT COMPONENTS AND ASSEMBLIES. H. N. Bass, D. L. Fischer, T. J. Pashos, and B. Wolfe. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

This reactor was designed and fabricated for installation at Lockheed's Nuclear Facility at Dawsonville, Georgia. Its purpose is to provide a facility for determining radiation effects on assemblies too large to be irradiated in experimental tubes or beam ports. This is a high radiation leakage reactor which will operate in air in an irradiation building with assemblies placed adjacent to the reactor for irradiation. The reactor is a pressurized water cooled and moderated reactor contained in a long slender pressure vessel, using MTR type, Al clad, flat plate, U–Al alloy fuel elements highly enriched in U^{235}. (M.H.R.)

14982 A/CONF.15/P/414

General Electric Co. Atomic Power Equipment Dept., San Jose, Calif. and Kaiser Engineers Div., Henry J. Kaiser Co., Oakland, Calif.

THE DESIGN AND CONSTRUCTION OF THE ETR, A 175,000 KW ENGINEERING TEST REACTOR. J. Barnard, P. D. Bush, E. R. Kilsby, and W. M. Malott. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Engineering Test Reactor is a light water moderated and cooled, beryllium reflected reactor providing large quantities of in-core test space. The reactor contains 49 fuel elements. Each fuel element consists of 19 uniformly spaced, fully enriched uranium-aluminum alloy fuel plates clad in aluminum. Maximum heat flux is 1,150,000 Btu/hr sq ft with a maximum metal surface temperature of 280°F and a coolant flow of 35 ft/second. The fuel contains boron as a burnable poison. Reactor control is accomplished by 4 black and 12 grey fuel compensating control rods. The black rods are used for safety and shutdown. The grey rods have approximately the same absorption cross section as the fuel elements and when used for shimming, eliminates the problem of large neutron flux distortions. The fuel and control sections of the control element are independently replaceable. The control elements are mounted to the bottom of the reactor pressure vessel. Other novel features include the design of facilities to accommodate experimental piping which will penetrate the 200 psi pressure vessel. Auxiliaries are provided to accomodate experimental facilities and include supports, removal tools, and guidance devices within the reactor. (auth)

14983 A/CONF.15/P/415

General Electric Co. Vallecitos Atomic Lab., San Jose, Calif. and General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.

DESIGN AND SAFEGUARDS CONSIDERATIONS OF THE THIRTY MEGAWATT GENERAL ELECTRIC TEST REACTOR. R. K. Andersen, W. M. Cegelski, E. Janssen, M. J. Larocco, T. J. Pashos, W. A. Pitt, W. S. Prince, and B. Wolfe. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A review is presented of the design, construction, performance characteristics, and safeguards considerations of the 30-Mw General Electric Test Reactor under construction at Vallecitos. The heterogeneous core, cooled and moderated by light water, is contained in a slender Al pressure vessel submerged in a water pool. Experimental facilities may be placed in both the large irradiation zone of the pool and the high flux zone of the reactor core. The reactor is cooled by a primary system which transfers heat to a secondary system for dissipation in a cooling tower. The reactor coolant system, experimental facilities, and servicing canal are housed in a four-story concrete structure enclosed in a steel containment vessel. Supporting facilities are described. (M.H.R.)

14984 A/CONF.15/P/416

Westinghouse Electric Corp. Atomic Power Dept., Pittsburgh.; Bureau d'Etudes Nucléaires, S. A., Brussels.; and Société Belge pour l'Industrie Nucléaire, Brussels.

BELGIAN THERMAL REACTOR (BR-3). A. R. Del Campo, Pierre Erkes, and Guy Tavernier. 8p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The BR-3 may be the first commercially purchased nuclear power plant and the first nuclear power plant designed and fabricated in the United States for export. It is a pressurized water plant. Capacity will be 11.5 Mwe. Its core will consist of uranium oxide pellets contained within stainless steel tubes. The core will have two regions. The initial enrichment of the outer half will be 4.43%, that of the inner, 3.29%. Operating pressures are to be 2000 psia in the primary system and 520 psia in the steam side. The steam will be dry but saturated. The rods will be of silver-indium-cadmium, and will be supplemented by a boron compound in solution for cold shutdowns. (auth)

14985 A/CONF.15/P/417

[Massachusetts Inst. of Tech., Cambridge.]

MIT RESEARCH REACTOR. T. J. Thompson. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The MIT Research Reactor is cooled and moderated by heavy water and fueled by enriched U^{235}. Its normal operating power is one Mw, but it has the capability of operating at five Mw at a later time. This can be done by adding an additional heat exchanger and cooling tower. The reactor design incorporates several unique features including a medical research facility beneath the reactor, a flexible fuel arrangement, special safety features, and a variety of research facilities. Because it is located in a metropolitan area, the reactor is contained in an air tight shell which has several unusual safety features. Since this reactor is the prototype of several others proposed or under construction (Italy-U.S.A.), the reactor design and the site layout is described briefly. (auth)

14986 A/CONF.15/P/418

Illinois Inst. of Tech., Chicago. Armour Research Foundation.

THE FIRST INDUSTRIAL RESEARCH REACTOR FACILITY DESIGN, OPERATIONAL EXPERIENCE AND RESEARCH PROGRAMS. L. Reiffel. 27p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The program and facilities of the first reactor in the U. S. designed and constructed specifically for industrial research is described. Non-routine aspects of the health physics program and personnel control procedure are presented. Operating experience with the 50 kw aqueous-homogeneous design is discussed, and data are included on demand for cost of equipment and manpower during both routine operation and in times of reactor malfunction. The physical design of the reactor, the containment system and the supporting laboratories is outlined along with pertinent cost data. (auth)

14987 A/CONF.15/P/419

Los Alamos Scientific Lab., N. Mex.

APPLICATIONS OF GODIVA II NEUTRON PULSES. T. F. Wimett and J. D. Orndoff. 24p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Photographs of Godiva I and II are shown. Some of the observed properties of fission bursts are presented showing their relation to theory together with examples of a number of different experiments utilizing Godiva I and II bursts, such as: effects of dosage rates on mammals, irradiation studies, instrument response studies, and transient radiation effects in elementary materials. (M.H.R.)

14988 A/CONF.15/P/420

Oak Ridge National Lab., Tenn.

DESIGN AND OPERATION OF THE ORR. T. E. Cole and J. A. Cox. 46p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The ORNL Research Reactor is a general purpose, high flux, research tool designed to meet the needs for thermal neutron fluxes of 10^{14} n/cm^2-sec. The physical arrangement combines the high flux of an MTR-type reactor with some of the ease of access exemplified by pool-type reactors. The result is a long narrow pool of water with the reactor tank mounted on the bottom near one end. Beam tubes and two engineering test facilities (5.5 ft diameter) penetrate the walls of the pool to provide access for experiments. The pool of water provides shielding above the reactor and allows easy access from this direction. The reactor coolant (H_2O) is separate from the pool water in order to minimize contamination of the pool water. The control rod drive mechanism is located below the reactor in order to allow more room for experimental equipment above the reactor. Sufficient space is available in the pool for storage of hot fuel elements, a gamma irradiation facility, and irradiated experimental equipment. Materials Testing Reactor fuel elements, shim-safety rods, and beryllium reflector elements are used. The major problems in design centered around achieving ease of access to the high flux region, the gamma heating problem, the safety release mechanism for the control rods, and the water activity problems. The design considerations and the solutions of these problems are discussed. The start-up phase, including the hydraulic flow tests, critical operation, flux mapping, and initial operation at power, is discussed in terms of comparison with predicted behavior based on the design. Operation of the reactor at power is discussed with particular emphasis on the problems encountered in

the water system, and on radiation and contamination problems. The ORR operating organization is described and operating experience, down-time data, and operating procedures are discussed. Cost figures covering the design and construction of the facility are presented. (auth)

14989 A/CONF.15/P/421

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

THE OMRE–A TEST OF THE ORGANIC MODERATOR-COOLANT CONCEPT. C. A. Trilling. 54p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

This paper presents a description of the OMRE and its associated facilities and an analysis of the results obtained from its operation. Rates of radiation damage to the hydrocarbon under various conditions of power operation and effects of this damage upon the operation of the reactor are discussed. Preliminary conclusions are presented on the feasibility of the concept of an organic moderated and cooled power reactor. (auth)

14990 A/CONF.15/P/422

Battelle Memorial Inst., Columbus, Ohio.

EXPERIENCE WITH A 1-MEGAWATT POOL RESEARCH REACTOR. J. N. Anno, A. M. Plummer, and J. W. Chastain. 56p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A general introduction is given which states the reasons for choosing a one-megawatt pool-type reactor and briefly reviews the design and construction experience. A description of the reactor, building, and reactor site is then presented with a brief mention of costs. The operating experience is presented in two discussions: the first treating the pre-routine operation, and the second the routine operation experience. In the first discussion the experiments performed prior to continuous one-megawatt operation are described and the problems which appeared during this period are related. Finally, the experiences obtained in the routine operation of the reactor to provide radiations for experimentation are described. These experiences include the day-by-day problems as well as the several larger difficulties which have arisen. (auth)

14991 A/CONF.15/P/423

Argonne National Lab., Lemont, Ill.

DESIGN OF A HIGH FLUX RESEARCH REACTOR: MIGHTY MOUSE. L. E. Link, C. N. Kelber, R. H. Armstrong, R. F. Dickson, J. B. Heineman, R. R. Rohde, and W. R. Ware. 22p. $0.50(OTS).

Prepared for the Second U. S. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Mighty Mouse Reactor is a research reactor designed to produce a peak unperturbed thermal flux of 5×10^{15} n/(cm^2)(sec) and to provide a thermal flux over 10^{15} n/(cm^2)(sec) in a relatively large volume of the reflector. The reactor uses heavy water as coolant, moderator and reflector. The fuel is highly enriched U^{235} contained in and clad with magnesium. The reactor power level is 250 mw. The design provides about 70 experimental facilities. Among these are a vertical thimble in the highest flux which is of particular value in producing isotopes requiring multiple order reaction; horizontal beam holes into high-flux zones for use in diffraction work; and cryostat facilities for low-temperature irradiations and for production of low temperature neutrons. (auth)

14992 A/CONF.15/P/424

Brookhaven National Lab., Upton, N. Y.; Brussels. Centre d'Etudes pour les Applications de l'Energie Nucleaire.; North Carolina State Coll., Raleigh.; and General Nuclear Engineering Corp., Dunedin, Fla.

PRELIMINARY DESIGN OF A HIGH FLUX, EPITHERMAL RESEARCH REACTOR FOR THE BROOKHAVEN NATIONAL LABORATORY. T. Auerbach, J. Chernick, J. Juliens, G. Lellouche, and W. Zinn. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A parametric study of small high flux reactors for experimental purposes was carried out at BNL. Emphasis was placed on obtaining a high intermediate flux in the core and a high thermal flux in the reflector. D_2O was chosen as the moderator and coolant. The core size is sufficient to allow the simultaneous approach of several beam holes for neutron spectrometry work. The fuel elements are aluminum clad plates of enriched U-Al alloy of the MTR type. With this design and a D_2O or Be reflector it is expected to get an epithermal flux of about 10^{15} n/cm^{2}sec. in the core and a thermal flux of about 10^{14} n/cm^{2}sec. in the reflector at a total power of 20 Mw. Parametric studies were made to determine the effect of varying D_2O/uranium ratios, H_2O contamination, varying reflector thickness and different reflector materials on the critical mass and the space and energy dependence of the flux. The effect of xenon poisoning, as well as the effect of varying spatial distribution of uranium to eliminate the sharp power peak near the core-reflector boundary were also investigated. All calculations employed the multigroup diffusion method and were run on the Univac and the IBM 704. (auth)

14993 A/CONF.15/P/431

Los Alamos Scientific Lab., N. Mex.

ANALYSIS OF PROMPT EXCURSIONS IN SIMPLE SYSTEMS AND IDEALIZED FAST REACTORS. W. R. Stratton, T. H. Colvin, and R. B. Lazarus. 26p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

To analyze conceptual fast reactor accidents, two spherical models are used. These are (1) a homogeneous core in which all core material is assumed to be molten and at a relatively low density, and (2) a heterogeneous system in which the uranium is assumed to be in the form of spherical shells each of which is separated by low density material or void. In case (1), a nonlinear equation of state is appropriate, and the concept of "threshold" is important. In case (2), a normal equation of state is applicable. The analytic theory is applied to the first model. This theory shows a strong dependence of the explosive energy release on the "free" energy, Q, which can be produced without causing disassembling accelerations. For Q = 0, the total energy release varies as the cube of the excess reactivity. In the limit of large Q, the explosive energy varies as the $^3/_2$ power of the excess reactivity and is generally much larger than the total energy for a comparable system with Q = 0. The differential calculation is applied to both spherical models. In this case the motion of various portions of the core and reflector is followed in detail. A general survey is described in which the various parameters of importance to conceptual accidents are isolated and described. Comparison to the analytic theory is made for a few special cases. (auth)

14994 A/CONF.15/P/433
MSA Research Corp., Callery, Penna.
ACTIVITY DISTRIBUTION FROM SIMULATED PRESSURIZED WATER REACTOR LEAKS. J. W. Mausteller and R. J. Campana. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A series of studies was made of the behavior of selected isotopes in water leaking to the atmosphere from systems operating at conditions representative of water cooled reactor systems. Tests with soluble (Na-24 as Na_2CO_3), insoluble (Mo-99 as MoO_3), and volatile (I-131 as I_2) species are described. A pumped 180 liter system at 550°F, 2000 psi was allowed to leak into a 4000 cu ft enclosure, using leaks of various types: 7 and 10 mil holes in pipe walls, both bare and lagged; gaskets between flanges; valve seats and glands; and steam phase. Leak rates ranged from 1 to 100 lph, over periods up to 24 hr. Airborne activity was of special interest but material balances also were made of activity on surfaces and in condensate. Measurements were made of fallout rates, airborne particle size ranges and associated activity, effects of such parameters as total solids in leaking water, wall temperature, added steam, a 350°F water temperature, humidity, etc. (auth)

14995 A/CONF.15/P/434
Illinois Inst. of Tech., Chicago. Armour Research Foundation.
SOME HYDRODYNAMIC PROBLEMS IN REACTOR CONTAINMENT. F. B. Porzel. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

This paper summarizes briefly the main features of some hydrodynamic problems in the design of reactors for containment against internal explosions. The pertinent conclusions which summarize this experience are as follows and apply to explosions in various solid and liquid media: the Rankine-Hugoniot equations are of general applicability to both shocks and strong pressure pulses; a large pressure change across a shock (thousands of bars) is equivalent to a small temperature rise (few degrees); a "waste heat concept" is employed both for conservation of energy and as a model for the bona fide dissipation of energy across a shock front; only a small fraction (like 1%) of the total energy appears as mechanical energy at long distances of practical interest from an explosion; the peak-pressure P versus distance R curve falls rapidly close-in ($P \sim R^{-7}$) until the dynamic crushing strength of the material is reached; the peak-pressure of the shock and the gradient behind it are so related that the total energy is relatively insensitive to the wave shape; there is an enormous preference for hydrodynamic energy to flow into rarefied media (like 1000:1). Based on these hydrodynamic considerations, two techniques of reactor containment have been found most effective; a composite "blast shield" which effects an optimum conversion of mechanical energy to thermal energy by choice of specific materials (steel, wood, foam plastics) and a geometrical design; and through "channeling" which directs the blast energy away from critical structures and dissipates it innocuously over a large volume. Three other techniques of containment usually prove dissappointing: lengthening the duration of the energy release, isolation by air gaps and reflecting barriers. Hydrodynamic reasons are shown for the failure of these latter methods. (auth)

14996 A/CONF.15/P/435
Vitro Corp. of America, New York.
A GENERAL METHOD FOR EVALUATING CONTAINMENT SHIELDING UNDER NORMAL AND EMERGENCY CONDITIONS. L. Geller and Rita H. Epstein. 51p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

For the purpose of reducing costs some reactor installations are using external shielding around a containment vessel rather than localized shielding. Such shielding can be designed to be adequate both under normal and emergency conditions. In view of this a generalized treatment of such shielding has been attempted. Analytical dosage calculations may at present be performed with some degree of assurance only for simple sources in very simple geometrics. The case of spatially distributed sources behind a shadow shield has received only slight attention. In a series of calculations recently completed, the dosage at any ground point is computed when a reactor containment vessel, which is partially or fully shielded, is suddenly uniformly filled with gamma emitters. In order to quickly perform the numerical work via hand calculation, several simplifications are made. The spatially distributed source within the containment vessel is replaced by an anisotropic point source located at the center of containment; the number of photons emergent from the point source in any direction per unit solid angle being equal to the actual number leaving the containment vessel in the same direction per unit solid angle. The flux from this anisotropic source is then evaluated assuming that the dosage at a point of interest is due to an infinite distribution of isotropic point sources in the surrounding air, the strength of these sources being determined by single scattering probability with multiply scattered radiation being accounted for by a buildup factor. So as not to greatly overestimate the dosage near to the containment vessel, no scattering is allowed in a suitable volume of space surrounding the anisotropic source. (auth)

14997 A/CONF.15/P/436
Michigan. Univ., Ann Arbor.
A QUANTITATIVE APPROACH TO EVALUATION OF RISK IN LOCATING A REACTOR ON A GIVEN SITE. Henry J. Gomberg. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

As the use of nuclear energy as a prime heat source for electric power generation expands, the location of plants near population centers will occur more frequently. Economic and technical pressures will force the reduction in distance between the source and consumer of electrical energy generated from nuclear sources as it has from conventional fuels. The need for methods which can be used to evaluate the relative risk in locating a plant at different points within or near a populated power distribution area is necessary to provide a quantitative basis for determination of insurance rates. Ideally, to evaluate risk, one should know: (1) the probability that an incident will occur in which some amount of radioactivity will be released from the core into the building housing the reactor; (2) the probability that radioactivity will escape from the building; and (3) the probabilities of occurrence of the significant weather conditions which govern the duration and intensity of radiation exposure to which some part of the surrounding population will be subjected. To proceed with the

evaluation of a proposed site one must know: (1) the population distribution around the site out to a radius of x miles (x is a function of reactor power); (2) the weather conditions at the time of release of radioactivity and for many hours thereafter (wind direction, wind velocity, and vertical temperature gradient); (3) the nature of the terrain, whether flat or hilly, rough or smooth, existence of major valleys, etc.; and (4) amount of material released as gas and as particulate matter of a given size distribution. To assist in calculation, it is assumed that reactor operation has taken place over some specified period of time and at a specified power level. With a suitable model for the behavior of a contaminant in the atmosphere, such as that defined by Sutton's Diffusion Theory, isodose contours for external gamma exposure and for the inhalation of beta emitters under a given set of weather conditions can be established. Using these isodose contours together with the population data, it is possible to calculate the number of persons affected by a given dose level for a postulated set of weather conditions. (auth)

14998 A/CONF.15/P/437
Argonne National Lab., Lemont, Ill.
REACTOR CONTAINMENT. R. O. Brittan and J. C. Heap. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A survey is presented of the technical and economic aspects of the containment problem and an accounting of the work in the United States which is providing solutions to various facets of the problem. Studies show that release to the atmosphere of radioactive contents of reactors operating at useful power levels results in a public disaster in populated regions. In lieu of isolation to wilderness areas, the U.S. reactor industry has selected containment in a highly restricted space. This approach results in a number of problems to which solutions are being sought on an ad hoc basis by the reactor builders and from a more general and continuing standpoint under sponsorship of the Atomic Energy Commission. Central station power reactors in the hundreds-of-megawatt range are the principal source of the problem and basis of the government-sponsored program. One class of problems arises from the nature of the energy releases motivating the radioactive materials and assaulting the barriers, and from the need to reduce the energy damage potential. The second class of problems is formed on an attempt to establish and maintain these barriers within economical bounds. The conditions leading to an assault on the barriers are assumed to initiate from accidents of three types: excess reactivity, loss of coolant, and coolant flow stoppage. These accidents result, one way or another, in abnormal release of nuclear, chemical, and/or stored thermal energies. The released energy is partially malignant and partially benign. Damage potential of the former, with respect to the primary structure of the reactor plant, must be assessed so that proper estimates can be made of the loadings on the outer barrier. (auth)

14999 A/CONF.15/P/440
Rensselaer Polytechnic Inst., Troy, N. Y. and Owens-Corning Fiberglas Corp. Research Center, Newark, Ohio.
GLASS FIBERS IN NUCLEAR REACTOR TECHNOLOGY. P. Harteck, S. Dondes, and J. W. Michener. 6p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A novel technique of incorporating fissionable and fertile material, homogeneously dispersed, in mineral or glass fibers, appears to have definite advantages for use in nuclear reactor fuel elements. To date, incorporation of 10% uranium-235 oxide by weight has been readily achieved. Radiation stability studies were made of these fibers, examining the effect of fiber diameter, tensile strength, and surface effects. Fibers of 1 to 5 μ diameter were shown to be excellent sources of fission fragments for utilization in the irradiation synthesis of chemicals, i.e., the nitrogen fixation process. Fibers of over 10 μ in diameter are being considered as matrices of fuel elements for power and materials test nuclear reactors. Some of the advantages of dispersing fissionable, including uranium-233, uranium-235 and plutonium-239, and fertile, including uranium-238 and thorium-232, material in glass fibers are; large surface area per unit, high chemical and thermal stability, adaptability to variations in composition, versatility in possible structural forms, and adaptability to simplified chemical reprocessing procedures. (auth)

15000 A/CONF.15/P/445
Los Alamos Scientific Lab., N. Mex.
A PROPOSAL FOR A MEGAWATT REACTOR EXPERIMENT UTILIZING A MOLTEN PLUTONIUM FUEL. R. M. Kiehn, L. D. P. King, R. E. Peterson, and E. O. Swickard. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Proposed design for LAMPRE I, formulated on the basis of known fuel alloy and container technology is as follows: A plutonium-iron eutectic alloy with a melting point of 410°C, will be held in a tantalum heat exchanger which serves as a core container and also permits removal of heat from the fuel by circulating sodium coolant. Since no breeding demonstrations will be attempted, a simple iron reflector, also sodium cooled, surrounds the core. This reflector, the core, and a gas-blanketed system for injecting molten fuel into the core, are enclosed in the main reactor vessel. Gaseous fission products escaping from the core are collected in the fuel metering system and vented through delay lines and absorber beds. Fuel density variation with temperature provides a strongly negative, prompt temperature coefficient of reactivity which facilitates reactor control. Reactivity adjustment, for a given fuel loading is effected by movable reflector segments external to the reactor vessel. Suitable modifications to these segments permit them to serve as reactor oscillators. Approximate values of selected design specifications and characteristics of the reactor experiment are summarized. (auth)

15001 A/CONF.15/P/447
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
THE DESIGN OF THE EXPERIMENTAL REACTOR FOR THE PLUTONIUM RECYCLE PROGRAM. R. M. Fryar. 28p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Since the reactor for the Plutonium Recycle Program is an experimental tool, the bases for its design stem directly from the incentives, the unknowns, and objectives of the program. The incentives of the program including the peaceful use of plutonium produced in both power and other reactors, the design flexibility and cycle economy from enrichment with dependence on high cost isotope separations facilities, and the three- to fourfold energy availability increase as a result of plutonium recycle are discussed. The technical unknowns of the fields of nuclear physics, metallurgy,

chemistry, and reactor engineering associated with plutonium recycle are identified. From these incentives and unknowns, the proposed Plutonium Recycle Program is derived. It is concluded that in order to accomplish the objectives of the program, a prime requirement is an irradiation facility from which can be obtained a variety of nuclear and metallurgical information. Since the reactor is a research and development tool, the prime prerequisite of the facility is to provide the maximum amount of flexibility in as many parameters as possible, consistent with safety and available funds. To secure this flexibility, the reactor was designed as a heavy water moderated and cooled, pressure-tube type reactor with a thermal power rating of 70 megawatts. The physical features of the reactor including the containment and service structures; the reactor core including calandria, process tubes, fuel element, and shielding; the heavy water process and moderator cooling systems; the moderator level control by the gas balance method; the helium gas system for primary circuit pressurization, reactor atmosphere and moderator level; and the supplementary mechanical shim controls are described. Emphasis is given to the underlying reasons for the selection of the design features on the bases of the flexibility criteria and the requirements of the parent research and development program. (auth)

15002 A/CONF.15/P/448

Oak Ridge National Lab., Tenn.

CHEMICAL ASPECTS OF MOLTEN FLUORIDE REACTORS. W. R. Grimes, F. F. Blankenship, G. W. Keilholtz, H. F. Poppendiek, and M. T. Robinson. 32p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Reactors which utilize circulating liquids as fuels pose serious problems in chemistry and chemical engineering as substitutes for the difficult mechanical problems of more "conventional" reactor designs. The Aircraft Reactor Experiment recently demonstrated the feasibility of such a reactor using a molten salt mixture as the circulating fuel. This paper describes what appear to be adequate solutions to many of the chemical problems of high-temperature reactors of this class. (auth)

15003 A/CONF.15/P/449

Oak Ridge National Lab., Tenn.

THE HOMOGENEOUS REACTOR EXPERIMENT NO. 2 S. E. Beall and W. D. Burch. 50p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Homogeneous Reactor Test is a 5 Mw aqueous homogeneous reactor. The purpose and design details were presented in Paper 526A of the 1955 Geneva Conference. The present paper relates the experiences with this reactor through the construction, engineering testing, and startup phases. Construction and hydrostatic testing of the reactor container were completed in the fall of 1955, and the reactor and chemical plant components were installed from October 1955, to May 1956, at which time engineering testing of the systems began. These tests were interrupted to replace stainless-steel flanges and leak-detector tubing that were damaged by stress-corrosion cracking resulting from chloride contamination in the leak-detector system. The engineering tests were completed in December 1957, and reactor operation was begun in January 1958. The engineering tests, critical experiments, and operation of the reactor at power are described. Similar information is also presented for the chemical plant, which is attached to the reactor system, although in a separate shielded cell, to demonstrate the continuous purification of the fuel solution. The performance of the chemical plant is discussed with respect to the continuous removal of the insoluble corrosion and fission products. Also described is the manner in which the recovered solids are processed to remove the heavy water and to accomplish solution in a light water, sulfuric acid medium, so that a homogeneous sample of the removed material can be used for evaluation of the plant. The development of remote maintenance techniques, the maintenance experience and process improvements are described in detail. (auth)

15004 A/CONF.15/P/452

[Atomics International Div., North American Aviation, Inc.]. Canoga Park, Calif.

OPERATING EXPERIENCE WITH THE SODIUM REACTOR EXPERIMENT. F. E. Faris, D. H. Johnson, J. E. Owens, L. E. Glasgow, R. W. Campbell, and G. E. Deegan. 47p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The main conclusions to be drawn from the operation of the SRE indicate that the plant has performed extremely well at levels up to ⅓ of full power. The performance of the reactor and reactor steam plant complex is extremely stable. Excess thermal stresses are not an inherent characteristic of sodium cooled reactors. With the information gained from the SRE it should be possible to design a sodium cooled reactor free from these stresses. With the exception of the boiling toluene cold traps, all of the components developed for the SRE have performed well. For large sodium systems free flow through 1½ in. and smaller lines is determined by the sodium oxide precipitation temperature rather than by the melting point of sodium. Maintaining the oxygen concentration at or below an indicated level of 10 ppm can be easily accomplished under normal operating conditions. Maintenance and modifications of the main primary and secondary sodium systems can be directly and easily accomplished. The shielding for the SRE is more than adequate. In particular the gap tolerances are more stringent than necessary and economies can be realized in future reactor designs by relaxing them. The gamma heating of concrete structures greatly accelerates the dehydration rate. Reasonably good agreement has been obtained between the calculated and measured critical masses, individual worths of core elements and the flux distribution. The slow-acting over-all isothermal temperature coefficient for the SRE is positive but small. The fast-acting metal coefficient is negative and large. (auth)

15005 A/CONF.15/P/453

Westinghouse Electric Corp. Atomic Power Div., Pittsburgh and Division of Reactor Development, AEC.

THERMAL AND HYDRAULIC EXPERIMENTS FOR PRESSURIZED WATER REACTORS. W. H. Esselman, I. H. Mandil, S. J. Green, P. C. Ostergaard, and R. A. Fredrickson. 48p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The results of an analytical and experimental program to obtain knowledge concerning thermal design unknowns for pressurized water reactors are described. Experimental techniques used are described. The out-of-pile tests simulated nuclear heating by using electrically heated test sections. The in-pile experiments were performed with specially instrumented and loaded

fuel elements installed in a reactor to measure appropriate thermal and hydraulic conditions. Results on the following subjects are included: experiments on the surface effects of nucleate boiling; pressure drop tests; heat transfer burnout tests; transient loss-of-coolant-flow experiments with an operating reactor; and reactor performance during operation at limiting thermal and hydraulic conditions. (M.H.R.)

15006 A/CONF.15/P/455
Argonne National Lab., Lemont, Ill.
ARGONNE LOW POWER REACTOR: A PROTOTYPE DIRECT CYCLE BOILING WATER REACTOR PACKAGE PLANT FOR ELECTRIC POWER PRODUCTION AND SPACE HEATING. C. R. Braun. 19p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The design and initial performance of a complete facility consisting of a direct cycle boiling water reactor, associated controls and power equipment, constructed at the National Reactor Testing Station by Argonne National Laboratory. The reactor is an enriched uranium-fueled, direct-cycle, water moderated, natural circulation boiling water prototype of package power plants designed to produce electric power (300 kw) and space heating (400 kw) for remote locations. (M.H.R.)

15007 A/CONF.15/P/458
Argonne National Lab., Lemont, Ill.
PREDICTED DYNAMIC BEHAVIOR OF EBR-II. T. R. Bump and H. O. Monson. 31p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Experimental Breeder Reactor-II is designed to operate with very high core power density (1.37 Mw/liter, max.) and high fuel temperature (1200°F, max.). Accordingly, even small perturbations in reactor power or coolant flow rate become potential sources of damage to the reactor. Therefore, extensive calculations were made to determine quantitative effects of disturbances considered likely to occur during normal reactor operation and those which would derive from certain postulated accidents. Three general types of perturbations are considered: (1) sudden cessation of reactor coolant pumping power, both before and after reactor scram; (2) small changes in reactor coolant pumping power, both with and without automatic regulation of reactor power; and (3) step changes in reactivity. The conclusions drawn from these calculations are presented and their effects upon EBR-II design and permissible operating conditions are discussed. (auth)

15008 A/CONF.15/P/459
Brookhaven National Lab., Upton, N. Y.
ENGINEERING EXPERIENCE AT BROOKHAVEN NATIONAL LABORATORY IN HANDLING URANIUM–BISMUTH REACTOR FUELS. R. J. Isler, C. J. Raseman, H. Susskind, and C. H. Waide. 22p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Techniques and equipment for handling the Bi–Mg–U–Zr fuel solution are described. (W.D.M.)

15009 A/CONF.15/P/460
Brookhaven National Lab., Upton, N. Y.
THE THORIUM BISMUTHIDE BREEDER BLANKET. J. S. Bryner and M. B. Brodsky. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A discussion is presented of those systems which might be considered for use as breeder blankets for the Liquid Metal Fueled Reactor under development at Brookhaven. The system thought to have the greatest potential as a Th-U^{233} breeder consists of a dispersion of thorium bismuthide intermetallic compound ($ThBi_2$) in liquid bismuth. The properties of the thorium bismuthide blanket are described and are used to present a unified blanket system. Results of slurry preparation by various techniques for laboratory use are presented and their applicability to a full size blanket is discussed. Thorium bismuthide particles can be prepared and retained in a nearly equiaxed shape but conditions are described under which less favorable shapes occur. The rate of particle growth was studied under various conditions of temperature and flow and indicated that particles 100 μ or less in diameter can be maintained under anticipated steady state conditions. Effects of additives on the crystal habit and growth rates of the particles were studied and are discussed. Problems associated with the design and operation of pumped test loops for this system are described. The results of such loop experiments are given. Possible methods are described for the processing of the slurry for the removal of the bred Pa^{233} and U^{233}. A simple pyrometallurgical process seems feasible if the bred products can be transferred quickly to the liquid bismuth phase. The transfer of bred products has been studied isothermally and with temperature operations which dissolve all or part of the solids. The properties of the blanket system are used to predict the operating behavior of a full size blanket. Problems which remain to be solved are discussed and their effects on the usefulness of the system are predicted. (auth)

15010 A/CONF.15/P/461
Brookhaven National Lab., Upton, N. Y.
LIQUID METAL FUEL REACTOR WITH RECYCLED PLUTONIUM. F. T. Miles, T. V. Sheehan, D. H. Gurinsky, and H. J. C. Kouts. 21p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A liquid metal reactor (LMFR) fueled with recycled plutonium dissolved in bismuth is described. The LMFR plutonium burner discussed was designed to use technology developed for a proposed U^{233} breeder. The design is conservative in that it attempts to avoid the problem associated with two fluids in the reactor core, e.g., the leakage of fluids into graphite, internal heat transfer, and the settling of slurries. This LMFR is of the "pot type" design. A fuel solution might consist of bismuth containing a 2000 ppm equilibrium mixture of the plutonium isotopes, 1000 ppm of natural uranium, and 350 ppm of magnesium, and 250 ppm of zirconium as corrosion inhibitors. The fuel circulates through the graphite core to an external heat exchanger occupying a section of the graphite reflector. The conversion ratio in such a system is about 0.4. The design is compared with LMFR's fueled with U^{235}. At the present U.S. price of $17 per gram, U^{235} is a more economical fuel than plutonium at a guaranteed price of $30 per gram. This comparison is useful, however, in estimating a true value of plutonium as a fuel. (auth)

15011 A/CONF.15/P/465
General Electric Co. Aircraft Nuclear Propulsion Dept., Cincinnati.
TESTS OF A DIRECT CYCLE NUCLEAR TURBOJET SYSTEM. D. R. Shoults. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

This paper discusses research and development effort on a direct-cycle air-cooled nuclear reactor and

propulsion equipment. The reactor experiment was designed, constructed, and tested during the period 1953 to 1956 to prove the feasibility of operating a turbojet engine from the heat produced by an air-cooled reactor. A description is given of the reactor, turbomachinery, shielding, control system, and associated equipment used in the first propulsion system test which was run in 1956. The system consisted of a modified J-47 turbojet engine arranged so that compressed air from the compressor was ducted through a shielded reactor and a chemical combustor in series before passing through the turbine and exhaust nozzle. The experimental reactor was based on a unique design concept in which water moderator at low temperature is contained in an aluminum core structure. The air-cooled metal fuel elements containing enriched uranium were arranged in passages running through the reactor. Thermal insulation was provided to protect the aluminum structure from the high temperature fuel elements and air, and to reduce heat losses to the moderator water. The entire reactor shield and turbojet assembly was mounted on a four-rail flat car for easy transfer by a shielded locomotive from the test site to the maintenance facility, where reactor disassembly, repair, and maintenance were performed by use of remotely controlled handling equipment. A description of the test facility with its underground control room, instrumentation, and data processing system is presented as well as a description of the large maintenance facility and various types of remote handling equipment. Test operating experience is presented which includes data on the operating characteristics of the system; the nuclear, thermal, and mechanical behavior; the radiation levels experienced; and the remote disassembling, repairing, and servicing the propulsion system. The paper includes photographs and charts describing the equipment, facilities, and test operation. This test program proved the feasibility of operating a turbojet engine exclusively on nuclear power. During the series of tests, the total nuclear energy produced was greater than 5000 megawatt hours. (auth)

15012 A/CONF.15/P/466

Combustion Engineering, Inc., New York.

ECONOMY LOADING OF NUCLEAR POWER PLANTS IN STEAM ELECTRIC SYSTEMS. L. Macklin. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

With the growth of steam electric generating systems during the last thirty years, the relatively simple criteria which dictated how much load should be imposed on a given power plant or a given generating unit in a power plant was displaced by the techniques of incremental loading. Incremental loading results in the lowest cost of delivered energy for any electric generation and distribution system. On one hand, one might assume that the nuclear generating unit can pick up any incremental load with no incremental fuel cost; the reasoning being that unlike a fossil fired fuel unit where there is a visible consumption of fuel, the nuclear cost is all paid for and there is no obvious increment fuel cost—with the possible exception of burn-up. On the other hand, by recognizing that a given core has a limited life in terms of megawatt days a logical apportionment of the total nuclear fuel cost over the sum total of electrical energy generation results in proper economic electrical loading. After developing the theory of incremental—or economy—loading of steam electric systems, the results obtainable by the two approaches outlined for nuclear generating units in representative electric systems are presented. The method of apportioning each component of nuclear fuel cost and the effect of each component on the resultant system loading and total system generating costs are developed. (auth)

15013 A/CONF.15/P/495

Bureau of Mines.

USE OF NUCLEAR ENERGY FOR PROCESS HEAT. Harry Perry and James P. McGee. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Nuclear reactors for process heat offer ultimate advantages of high temperatures available at elevated pressures. Heat transfer from the reactor may be indirect, utilizing an inert gas to convey heat from the reactor to a separate heat exchanger, or direct to one or more reactants passed through the nuclear reactor. Nuclear process-heat reactors may eventually cover a range from the production of low temperature steam for chemical processing to the direct production of NO_2 at temperatures approaching 4,000°F. While conceivably applicable to almost any endothermic chemical process, nuclear process heat appears to have unique characteristics that favor its use in a synthetic fuels program. In countries where the cost of fossil fuels is relatively high, the use of nuclear process heat appears more advantageous than in the United States, which has relatively low cost coal, oil, and gas. (auth)

15014 A/CONF.15/P/541

Argonne National Lab., Lemont, Ill.

THE PYROMETALLURGICAL PROCESS AND PLANT FOR EBR-II. M. Levenson, G. Bernstein, J. Graae, L. F. Coleman, D. C. Hampson, and J. H. Schraidt. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Experimental Breeder Reactor-II plant will consist of a complete fuel cycle as well as a complete power cycle. The fuel cycle facility contains equipment for the determination of the technical feasibility of pyrometallurgical processing and remote refabrication of spent reactor fuel elements. The specific pyrometallurgical process selected for inclusion in this plant and the technical features of plant design are described. The main unit of the fuel cycle facilities is a sextodecagon hot cell. This shielded shop contains the equipment for the decanning step, the melt refining of the spent reactor fuel, the fabrication of new fuel pins and the assembly of new fuel elements. An ancillary shielded cell is used for the remote fabrication of complete subassemblies and for servicing of main cell equipment. (auth)

15015 A/CONF.15/P/590

Du Pont de Nemours (E. I.) & Co. Savannah River Lab., [Augusta, Ga.].

PHYSICS OF NATURAL URANIUM LATTICES IN HEAVY WATER. G. Dessauer. 43p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A survey of the reactor physics of natural U–D_2O systems is presented. Physical parameters of more than 250 different lattices were measured at the Savannah River Laboratory. Along with a physics analysis of the designs, consideration was given to the operability of the reactor. Possible instabilities arising from spontaneous redistribution of Xe, or from the coupling between neutron kinetics and heat exchange, were studied. Discussion and data are included on buckling measurements in cold, clean lattices; evalua-

tion of lattice parameters; the effects of H_2O in the moderator; temperature coefficients; and reactivity transients and core life. (M.H.R.)

15016 A/CONF.15/P/591
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
LATTICE PARAMETERS DERIVED FROM NEUTRON DISTRIBUTION. W. E. Niemuth and R. Nilson. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Radial distributions of U^{235} and natural uranium fissions and of U^{238} neutron captures were experimentally determined in a variety of cylindrical solid, cored, and internally moderated, natural uranium fuel elements in graphite-moderated lattices. Together with suitable cadmium ratios and thermal flux traverses throughout the lattice cell, the data were reduced to yield the following parameters: thermal utilization, the fast to thermal fission ratio, the U^{238} resonance to thermal capture ratio, and the initial conversion ratio. In terms of the above parameters, the resonance escape probability, and the fast effect, are determined. (auth)

15017 A/CONF.15/P/592
Los Alamos Scientific Lab., N. Mex.
PROPERTIES OF ELEMENTARY FAST-NEUTRON CRITICAL ASSEMBLIES. G. E. Hansen. 15p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Typical properties of elementary fast-neutron critical assemblies studied at the Los Alamos Scientific Laboratory are tabulated. The kinetic, spectral, and perturbative properties of Godiva, Topsy, and their Pu analogs were studied in detail. Results of critical measurements are supplemented by data from uranium-metal exponential columns. The influences of shape and material composition on critical size are discussed. The properties of spherical U and Pu assemblies are covered. (M.H.R.)

15018 A/CONF.15/P/593
Oak Ridge National Lab., Tenn.
EXPERIMENTAL AND THEORETICAL STUDIES OF UNREFLECTED AQUEOUS U^{235} CRITICAL ASSEMBLIES. R. Gwin, D. K. Trubey, and A. M. Weinberg. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The empirical kernel method for treating bare critical systems is discussed and is utilized to predict the material buckling of aqueous U^{235} bare reactors in an effort to clarify the age discrepancy. These results are compared with experimental critical and kinetic data which are also presented. In the comparison, it is found that the uncertainty regarding the proper experimental extrapolation distance arises and prevents an unambiguous comparison. (auth)

15019 A/CONF.15/P/594
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
EXPONENTIAL EXPERIMENTS ON GRAPHITE LATTICES WHICH CONTAIN MULTI-ROD FUEL ELEMENTS. R. A. Laubenstein. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A series of exponential experiments were carried out on graphite-moderated lattices containing multi-rod fuel clusters, in order to obtain information for design calculations on sodium–graphite power reactors. Measurements of the lattice buckling and intracell flux distribution were included. Experimental measurements of the critical mass with and without sodium in the core of the Sodium Reactor Experiment were intended as a check on the application of exponential experiment results to a critical assembly. (M.H.R.)

15020 A/CONF.15/P/595
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
EXPONENTIAL EXPERIMENTS WITH ORGANIC MODERATED URANIUM LATTICES. W. W. Brown. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A series of exponential experiments was carried out on lattices of cylindrical uranium metal rods in a moderator of diphenyl. Three different concentrations of U^{235} in uranium were available for study, 0.50, 0.72, and 0.91 at. %. The fuel rods were arranged in square lattice arrays at moderator to fuel volume ratios 1.5, 2, 3, and 4. A cadmium clad $2\frac{1}{4}$ ft diameter aluminum tank was used to hold the lattices. External heaters maintained the contents at 185°F, just above the melting point of diphenyl. The lattices were driven by neutrons from the thermal column of a water boiler reactor. Foil activation techniques were employed to make the buckling and intracell flux distribution measurements. Measurements in pure and borated diphenyl were made in order to obtain the thermal neutron diffusion length and transport mean free path in diphenyl. Buckling and intracell measurements were made for some lattices in the borated diphenyl in order to determine the neutron age in these lattices. (auth)

15021 A/CONF.15/P/596
Westinghouse Electric Corp. Bettis Plant, Pittsburgh.
TEMPERATURE COEFFICIENT MEASUREMENTS OF LIGHT-WATER MODERATED HETEROGENEOUS CRITICAL ASSEMBLIES. S. H. Levine, B. H. Noordhoff, J. J. Taylor, and W. F. Vogelsang. 23p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A series of critical experiments on heterogeneous, zirconium, light water moderated assemblies in simple geometry is summarized. The assemblies consist of both uniform highly enriched media and seed-blanket slab arrays containing a natural uranium alloy blanket in plate form. A review is given of the typical experimental techniques and experimental data obtained in the process of validating power reactor designs involving these core media. The discussion is divided into two parts; the first covering experimental techniques and the second covering certain of the data obtained. (auth)

15022 A/CONF.15/P/596(Add. 1)
Westinghouse Electric Corp. Bettis Plant, Pittsburgh.
CONFIRMATION OF NUCLEAR DESIGN METHODS THROUGH THE ANALYSIS OF A HETEROGENEOUS CRITICAL ASSEMBLY. R. J. Breen. 11p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A nuclear design model was developed to describe heterogeneous reactors containing highly enriched U and using H_2O as a moderator and reflector. Originally, this model did not include a scheme for evaluating the epithermal constants for a cross-shaped Hf control rod. Since the analysis of critical assemblies without control rods showed the model would calculate the multiplication factor satisfactorily for an unrodded

reactor, experiments were designed with control rods inserted. These are analyzed to yield a value for the epithermal cross section of cross-shaped control rods that would give the least error in the calculated multiplication factor for the experimental conditions. (M.H.R.)

15023 A/CONF.15/P/598

Argonne National Lab., Lemont, Ill.

FAST NEUTRON POWER REACTOR STUDIES WITH ZPR-III. J. K. Long, W. B. Loewenstein, C. E. Branyan, G. S. Brunson, F. S. Kirn, D. Okrent, R. E. Rice, and F. W. Thalgott. 44p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Argonne's critical facility, ZPR-III, is briefly described. More than 30 different assemblies of widely varying geometries and compositions were studied in this facility, most of which were to aid in the development of fast power breeder reactors. A description of the ZPR-III assemblies, tables of central reactivity coefficients, prompt neutron data, fission distributions, multigroup constants, critical masses, and other data from these experiments are presented. (M.H.R.)

15024 A/CONF.15/P/599

Argonne National Lab., Lemont, Ill.

EXPERIMENTAL AND THEORETICAL STUDIES OF THE COUPLED FAST-THERMAL SYSTEM, ZPR-V. H. H. Hummel, C. E. Cohn, G. J. Fischer, W. Y. Kato, F. H. Martens, D. Meneghetti, and B. J. Toppel. 33p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The zero-power reactor ZPR-V consists of a central fast core region separated from an outer annular water-moderated region by a blanket of natural uranium. The fast core composition is typical of a dilute power breeder and has a U^{238} to U^{235} ratio of 5. System characteristics such as flux distributions, neutron energy spectra, effect of change in fuel loading, and effect of change in blanket thickness, have been studied experimentally. The energy spectrum in the fast core is similar to that in the core of a dilute fast breeder; therefore a study of the spectrum, of reactivity effects, and of activation rates provides useful checks of fast neutron parameters. A careful review has been made of the fast neutron cross sections of U^{235} and U^{238} to provide improved multigroup parameters. Multigroup diffusion theory calculations using these new parameters are employed to compute the statics of the over-all system for comparison with experiment. Selengut-Goertzel slowing-down is used in the water region. (auth)

15025 A/CONF.15/P/600

Argonne National Lab., Lemont, Ill.

PROPERTIES OF EXPONENTIAL AND CRITICAL SYSTEMS OF THORIA–URANIA AND HEAVY WATER, AND THEIR APPLICATION TO REACTOR DESIGN. W. C. Redman and J. A. Thie. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Physics statics information was obtained through a series of heavy water exponential and critical experiments employing quarter-inch diameter fuel rods with thorium-U^{235} atom ratios of 25 and 50. Bucklings were determined for exponential triangular lattices of $1\frac{1}{2}$ to $7\frac{1}{2}$ in. pitch. Void and temperature coefficient of buckling also were measured. Systems of concentric zones having different bucklings were investigated. Critical experiments with a $\frac{3}{4}$ in. triangular lattice spacing and height to diameter ratios from 0.8 to 2.8 gave buckling and reflector savings information. Migration area was determined both by differential water worth and by variation of enrichment. Reactivity worth of voids and control rods was investigated. Thermal utilization and resonance escape were also measured. Physics considerations in boiling reactor design are assisted by these statics experiments and also the observed operating characteristics of BORAX-IV. In seeking compatibility among reactivity, void coefficient, conversion ratio, safety and stability, yet heeding boundary conditions imposed by mechanical, hydraulic and heat transfer considerations, judicious compromises are necessary. Illustrative of these design principles, a small 40 Mw ThO_2-UO_2-D_2O prototype boiling reactor having 400 kw/liter of coolant is presented. Although quite small, its attractiveness is further enhanced when extrapolated in size and power to those of practical interest. (auth)

15026 A/CONF.15/P/604

General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.

ADVANCED DESIGN OF A THERMAL SODIUM COOLED REACTOR FOR POWER PRODUCTION. S. Levy, B. G. Voorhees, P. G. Aline, and K. P. Cohen. 29p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An advanced thermal reactor utilizing sodium as the coolant is evaluated as a possible route to economical nuclear power. A central station power plant of 200,000-kw net output is described in detail, and an appraisal is made of its present and potential capital and fuel costs. Particular emphasis is placed upon novel design concepts, critical component items, and plant and nuclear analysis as they primarily affect costs. (auth)

15027 A/CONF.15/P/605

Oak Ridge National Lab., Tenn.

MOLTEN FLUORIDE POWER REACTOR. H. G. MacPherson, H. W. Savage, R. C. Briant, et al. 30p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A design study of a homogeneous, circulating fuel, power breeder reactor is presented. One of the desirable salt mixtures contains about 60% Li^7F and 40% BeF_2; it has a melting point of 850°F and a slowing-down power about 60% that of graphite. With isotopic composition of 99.99% Li^7, a homogeneous spherical reactor 8 ft in diameter will be critical with as little as 0.05 mole % UF_4, with a critical mass of 50 kg of U^{235}. The 8-ft reactor would be capable of producing 1900 Mw. (W.D.M.)

15028 A/CONF.15/P/608

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

THE SODIUM GRAPHITE REACTOR POWER PLANT FOR CPPD. R. L. Olson, R. C. Gerber, R. B. Gordon, H. A. Ross-Clunis, and J. F. Stolz. 34p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The plant arrangement, component design, and the functions of various systems are described and illustrated. Relative estimated costs of the systems and major components are indicated. The reactor core is designed around requirements for 254 thermal megawatts, 950°F maximum sodium temperature, stainless steel clad graphite moderator blocks, and low enrichment (0.015 to 0.04 U^{235}) uranium fuel elements. The fuel cycle is described for the possible fuel elements.

The fuel cost factors are discussed. Burn-up limitations encountered for metallic fuel in the SGR temperature range indicate UO_2 to be the more desirable choice. The estimated cost of electrical energy associated with the UO_2 fuel is given. (auth)

15029 A/CONF.15/P/610
DuPont de Nemours (E. I.) & Co. Wilmington, Del.
HEAVY WATER MODERATED AND COOLED POWER REACTORS. Dale F. Babcock. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A brief description is given of the experience gained at the Savannah River Plant in the handling of large quantities of D_2O. Work on a program for power reactors using natural U fuel and D_2O as moderator is described. Drawings of two types of such reactors are presented, and their characteristics are tabulated. (M.H.R.)

15030 A/CONF.15/P/617
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
EFFECT OF BURNUP ON METALLIC FUEL ELEMENTS OPERATING AT ELEVATED TEMPERATURE. B. R. Hayward and G. G. Bentle. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The phenomenon of swelling or large increase in volume that occurs in reactor fuels beginning at 400 to 500°C was observed for both uranium base and thorium base metals fuels. Radiation data were obtained from temperature monitored fuel specimens. The distortion of unalloyed unrestrained uranium at these surface temperatures results in a short fuel cycle and thus high cost fuel. The limitations imposed on fuel life are also directly affected by the specific fuel element design. The volume increase appears to be a function of temperature and % burnup. (auth)

15031 A/CONF.15/P/625
RAND Corp., Santa Monica, Calif.
EXTERNALLY MODERATED REACTORS. G. Safonov. 34p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A theory for the analysis of thermal externally moderated reactors due to G. Bell, Los Alamos, and G. Safonov, RAND, is described. The Fermi age model is employed for the description of neutron densities in the moderating reflector and the interior densities are determined by models suitable (a) to the low solidity cores and (b) to the high solidity cores. Theory is applied to a broad critical parameter survey of systems with low solidity cores employing U^{235}, U^{233} and Pu^{239} for fuel and D_2O, C, and Be for moderating reflector. It is indicated that gaseous fuel cores with diameters ranging down to ~0.5 meters may achieve criticality at less than atmospheric pressure. The liquid metal cores with U^{235}–Bi are found to require less fissionable material with the introduction of interior voids. Typical neutron flux profiles are presented and U^{233} breeding potentialities illustrated. A general discussion of possible applications of the externally moderated concept with particular reference to the engineering test and research reactor field is included. (auth)

15032 A/CONF.15/P/628
Oak Ridge National Lab., Tenn.
THE HIGHEST THERMAL-NEUTRON FLUXES OBTAINABLE FROM FISSION REACTORS. William Krasny Ergen. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The highest thermal-neutron fluxes obtainable from fission reactors, if limits are placed on the power density or total power, are investigated. Two cases are studied: a homogeneous reactor and a "flux trap" reactor. The flux-trap reactor consists of a reactor with a moderator-filled cavity at the center. Emphasis is placed on the fundamental principles and limitations rather than on engineering and design. (M.H.R.)

15033 A/CONF.15/P/629
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
SOME TOPICS IN REACTOR KINETICS. E. Richard Cohen. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Boltzmann equation for the neutron distribution in a reactor is discussed. Analytic and numerical solutions are presented. The general results are illustrated with data on the performance of the SPERT and KEWB tests. (W.D.M.)

15034 A/CONF.15/P/630
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
REACTOR ANALYSIS OF THE ORGANIC MODERATED REACTOR EXPERIMENT AND COMPARISON OF EXPERIMENTAL RESULTS. R. O. Williams, Jr., R. F. Wilson, W. O. Allen, Jr., B. R. Moskowitz, and D. R. Muller. 23p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The analytical and experimental reactor physics associated with the Organic Moderated Reactor Experiment are summarized. Considerable attention has been given to the thermal constants of the system. Calculations of the cell have been performed in the diffusion approximation, the P_3 approximation, and the S_n approximation. The results of these cell calculations are compared with each other and with activation measurements made on a special experimental element. Criticality calculations were made using two-group and three-group models. Fast group constants were obtained from cross-section data and normalized to agree with experimentally determined second spatial moments in diphenyl and diphenyl-steel mixtures. Predicted critical masses and reactivities are compared with experimentally determined masses and reactivities. The calculated temperature coefficient of reactivity is compared with the experimentally determined coefficient over the temperature range 250 to 750°F. The calculated void coefficient is compared with measured void coefficients obtained using a special test element. Experimental void coefficients are given as a function of position in the core and these are compared with calculated statistical weights. Experimental control rod worths are compared with rod worth as calculated by a modified Nordheim-Scalettar method for a reflected reactor and the method of cells. Various assumptions concerning the absorption spectrum of the rods are compared. (auth)

15035 A/CONF.15/P/632
Knolls Atomic Power Lab., Schenectady, N. Y.
INTERACTION OF WEAKLY COUPLED REACTOR SYSTEMS, WITH APPLICATION TO THE "CONVERGATRON." J. C. Stewart. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Some properties of critical reactor systems which

can be decomposed into two or more nearly critical subsystems are discussed. Such systems may be said to be "weakly coupled." Some examples of this class of reactor are the coupled fast-thermal critical assembly of the Argonne National Laboratory, the "Convergatron" introduced by Borst of New York University, and in fact any reactor whose core dimensions are sufficiently large compared to the neutron migration length. In such a system the over-all distribution of neutron flux and importance can be represented to a good approximation by a linear combination of the fundamental critical modes of the subsystems. The coefficients in this linear combination are readily found in terms of simple integrals over the subsystem critical modes, admitting easy physical interpretation as coupling parameters. A weakly coupled system which has generated much interest in recent months is the "Convergatron," in which the interaction between subsystems is, ideally, highly asymmetric; that is, neutrons are permitted to migrate much more readily in one direction than in the opposite direction. This type of coupling leads to the possibility of "amplification" of small neutron source to excite a high-power subcritical system. Some characteristics of this device are examined by the method outlined above; in particular, a relation emerges giving an upper bound on the margin of safety available at a given neutron amplification per stage. (auth)

15036 A/CONF.15/P/636

Westinghouse Electric Corp. Bettis Atomic Power Div., Pittsburgh.

SYNTHESIS OF THREE-DIMENSIONAL POWER SHAPES—A FLUX-WEIGHTING SYNTHESIS TECHNIQUE. J. E. Meyer. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An important step in analyzing the performance of a nuclear reactor is that of obtaining three-dimensional power shapes of various stages in the operating history of the reactor. These shapes are dependent upon the control rod configuration and upon the reactor operating history. The required distributions may be found at each stage of reactor lifetime combining a single one-dimensional and several two-dimensional power shapes with considerably less calculation than is required for a three-dimensional calculation. The two-dimensional results are obtained from neutron diffusion solutions in radial planes of the core, which include the details of the core and control rod geometry and the local effects of fuel depletion. The single one-dimensional distribution is calculated normal to these radial planes and parallel to control rod motion. Such a calculation provides not only a power distribution, but it allows the determination of critical control rod position and control rod worth. The synthesis technique is developed analytically by reducing the exact three-dimensional two-group neutron diffusion equations to a form which can be solved for flux and power shapes in radial planes. The radial solutions are then used to define certain flux-weighted material parameters. These parameters are used in the one-dimensional axial diffusion problem, and an axial normalizing function is obtained for each neutron energy group. From this the power normalization and the eigenvalue of the reactor can be calculated. Examples of solutions obtained by synthesis methods are compared with solutions of multi-dimensional problems. (auth)

15037 A/CONF.15/P/637

Argonne National Lab., Lemont, Ill.

THE PHYSICS OF FAST POWER REACTORS A STATUS REPORT. W. B. Loewenstein, and David Okrent. 41p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The nuclear performance of various conceptual fast power breeder reactor systems is reviewed in terms of existing experimental critical assembly data. A single set of nuclear constants serves to bridge the gap between existing experimental data and conceptual systems. Current knowledge of pertinent neutron cross-sections and fission parameters is reviewed. (M.H.R.)

15038 A/CONF.15/P/638

Argonne National Lab., Lemont, Ill.

THEORETICAL REACTOR STATICS AND KINETICS OF BOILING REACTORS. J. A. Thie. 13p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Theoretical expressions have been obtained for the stability margins under various operating conditions. A special case is the power at which self-sustained oscillations develop. The linearized reactor kinetics equations can be solved in combination with a system linear differential equation describing heat conductive and hydraulic processes. In this theory the reactor transfer function is:

$$G(s) = \frac{G_0(s)}{1 - KG_0(s) \prod_i \left(\frac{1 + T_i(s)}{1 + \tau_i(s)} \right)}$$

where $G_0(s)$ is the zero power transfer function, K is a constant, and T_i, τ_i are time constants associated with non-nuclear processes. The latter are had from analysis of three types of transfer function measurements: rod oscillation, rapid rod ejection, and autocorrelation of statistical power excitation. Comparisons between theory and experiment are encouraging. Thus, in view of their effect on reactor stability, these time constants now become an integral part of boiling reactor design criteria. (auth)

15039 A/CONF.15/P/705

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

RECENT DEVELOPMENTS IN THE TECHNOLOGY OF SODIUM–GRAPHITE REACTOR MATERIALS. R. L. Carter, R. L. Eichelberger, and Sidney Siegel. 32p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experimental results on core structural materials, moderator, and fuel materials are discussed. Data are given on grain growth of Zr and thermal conductivity, thermal expansion, and temperatures of various types of graphite. (M.H.R.)

15040 A/CONF.15/P/708

National Carbon Co., New York and Brookhaven National Lab., Upton, N. Y.

PHYSICAL PROPERTIES OF GRAPHITE MATERIALS FOR SPECIAL NUCLEAR APPLICATIONS. W. P. Eatherly, M. Janes, R. L. Mansfield, R. A. Bourdeau, and R. A. Meyer. 37p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A review of recent developments of low-permeability graphites and their evaluation specifically for the LMFR are presented. Liquid pickup and permeability, dependent on accessible void volume and pore spectrum,

govern the application of graphites in high-temperature gas-cooled and fused-salt reactor designs. A closely allied use is described in which graphite is compacted with uranium compounds to form fuel elements which may operate at 2000°C. The underlying physical principles which contributed to the attainment of the desired properties are discussed. (J.R.D.)

15041 A/CONF.15/P/745

Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Augusta, Ga.

RADIATION PROTECTION CONSIDERATIONS IN A HEAVY WATER MODERATED REACTOR. C. M. Patterson. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Radiation protection problems are reviewed for a heavy-water moderated, heavy-water-cooled, natural-uranium fueled reactor. The importance of and methods used in moderator purification and the characteristic radioisotopes encountered are mentioned. The following are discussed: tritium monitoring methods, controls for worker protection, treatment of the tritium hazard similarly to whole-body external radiation, and tritium assimilation–elimination experience. Other radioisotopes in the process water and conventional controls required are briefly noted. Equipment contamination is a problem during maintenance and is treated under normal shutdown, major overhaul shutdown, and fuel failure shutdown. Fuel discharge poses rather severe radiation control problems in the environment. Its direct relationship to fuel integrity and moderator purity is evident and methods for correction are suggested. The importance of continuous monitoring is stressed both from the operating viewpoint for system integrity as well as radiation protection. (auth)

15042 A/CONF.15/P/763

Argonne National Lab., Lemont, Ill.

DOSIMETRY OF γ-RAY AND NEUTRON FLUXES IN CP-5. Edwin J. Hart and P. D. Walsh. 11p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Water decomposition studies in the Argonne heavy water research reactor CP-5 illustrate the principles of γ-ray and neutron pile dosimetry. Pure water, irradiated by γ rays and neutrons in the core of CP-5, is stable. In contrast, water contaminated by free radical scavengers or by nuclear poisons such as boron decomposes into hydrogen and oxygen. These gases are liberated from the irradiated water in the ratio of 2 to 1 for steady state decomposition. The rate of gas evolution provides a measure of the neutron and γ ray fluxes. Solutions of potassium iodide, an efficient free radical scavenger, are used to monitor the γ-ray flux. And solutions of boric acid plus potassium iodide are used to find the sum of the neutron and γ-ray fluxes. The difference between the gas evolution rates for these two solutions yield data from which the thermal neutron flux may be calculated. The γ-ray and neutron flux patterns in the core and reflector regions of CP-5 operating at 1 megawatt will be discussed. The neutron flux depends on vertical position in the reactor core, varying from 1.7×10^{13} n/cm^2 sec in the center of a vertical thimble to 0.67×10^{13} n/cm^2 sec 18 inches higher. Gamma-ray fluxes in the core range downward from 6×10^6 rad/min. Iodide ion concentration has a marked effect on the rate of gas evolution. At a γ-ray dosage rate of 6×10^6 rad/min. at least 3×10^{-4} M potassium iodide is needed to produce the maximum rate of water decomposition. Below this concentration, partial recombination of hydrogen and oxygen occurs. Boric acid, in concentrations from 0.025 to 0.12 M, serves as a satisfactory neutron absorber. The lower concentration in this range is better for the fluxes in the core, the higher concentrations are better for the reflector fluxes. Approximately 60 ml of the iodide and boric acid solutions are irradiated in silica vessels loaded in the reactor in thin-walled aluminum cans. Aluminum capillary tubing (1/4" o.d., 1/8" i.d.) connects the silica cell with an external gas measuring apparatus. The rate of gas evolution is measured at constant pressure. Usually 15 to 30 minutes are required for a steady decomposition rate. (auth)

15043 A/CONF.15/P/785

Atomics International Div., North American Aviation, Inc., Canoga Park, Calif. and Nuclear Metals, Inc., Cambridge, Mass.

THORIUM–URANIUM FUEL ELEMENTS FOR SRE. B. R. Hayward and P. Corzine. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Thorium rich alloys of the Th–U systems are being used to develop data for development and evaluation of a Th-base fuel for high temperature and long burnup application. Results indicate a solubility of U in Th of 1 to 2% at 600°C. The development work for fabrication of large, sound, homogeneous ingots of high chemical quality is described. The processing phases following the vacuum ingot casting and the problems encountered are discussed. The various detailed process operations, specifications, and final results are presented. Approximately 250 kg of finished 3/4 in. × 6 in. slugs were produced. A series of Th–10% U alloys were irradiated to moderate burnup and high surface temperature at the MTR. Results indicate that some swelling occurs, but these alloys are substantially more radiation stable than unalloyed U and dilute alloys of U. (M.H.R.)

15044 A/CONF.15/P/787

Westinghouse Electric Corp. Bettis Plant, Pittsburgh.

MANUFACTURE OF THE SEED FUEL ELEMENTS FOR PWR. H. F. Turnbull, W. J. Hurford, L. B. Prus, and A. W. Klein. 13p. (WAPD-T-700). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A description of the seed is presented. The standard, instrumented, and source clusters are discussed and the method of forming the cruciform-shaped control rod channel is described. Manufacturing methods used in the production of the seed clusters are discussed. A description is given of the melting of the fuel alloy, together with the composition and fabrication of fuel plates. This includes both non-consumable and consumable electrode arc-melting techniques. The operations performed in cladding the fuel plates with Zircaloy-2 to provide corrosion resistance are described. The joining of the I-beam shaped fuel elements into 2 1/2 in. square subassemblies by fusion welding techniques is discussed. Finally, the formation of clusters of the subassemblies is described together with the accompanying heat treating, machining, inspection and testing operations. (auth)

15045 A/CONF.15/P/790

Argonne National Lab., Lemont, Ill.

FABRICATION OF THE URANIUM BASE FUEL PLATES AND ASSEMBLIES FOR THE EXPERIMENTAL BOILING WATER REACTOR. Robert E. Macherey. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The production of the uranium fuel alloy, the fabrication of the cladding components from Zircaloy-2 ingot, the assembly, welding, evacuation, and sealing of the cladding billets, the jacketing of cladding billets with steel, the roll bonding, heat treatment, stripping, and cleaning of the fuel plates, and the welding of fuel plates into fuel assemblies are discussed. Testing and evaluation of the fuel plates and assemblies produced are also included. The uranium core alloy was produced on a modest scale (170 kg) by the solution of alloying elements, Zr and Nb, in molten uranium. The use of graphite crucibles was made possible by a ceramic coating which reduced carbon contamination to the melt and consequently loss and segregation of the alloying additions. Costly and short-lived ceramic crucibles were made obsolete. The method used for the simultaneous pouring of multiple billet core castings to rough dimensions is discussed. The Zircaloy-2 cladding components were produced from double arc melted ingots by a sequence of forging, scalping, rolling, and cleaning operations. A description of the process by which stock satisfactory for use as cladding components is produced without resorting to extensive surface machining, is included. The cladding billet design which compensated for differential expansion between core and clad, took advantage of texture of the Zircaloy-2 end plug stock in establishing the bond between end plugs and side plates, and sealed Zircaloy-2 cladding components to exclude external contaminants from the bonding interfaces, is discussed. A unique method of vacuum arc sealing of the billet after evacuation is included. A steel jacket design and hot rolling practice were employed which produced plates to close tolerances and small camber. The isothermal heat treatment employed in developing irradiation dimensional stability in the core alloy, stripping, machining, and the final cleaning procedure employed for developing corrosion resistant surfaces without resorting to extensive over-all machining are described. The design of automatic tungsten arc spot welding equipment and the production operating practice employed in the joining of the fuel assemblies are described. The fuel assemblies were produced by welding six parallel fuel plates, spaced nominally $\frac{3}{8}$", to two perforated Zircaloy-2 side plates. (auth)

15046 A/CONF.15/P/791
Argonne National Lab., Lemont, Ill.
THE MANUFACTURE OF EBR-I, MARK III FUEL AND BLANKET RODS. Robert A. Noland, N. J. Carson, C. C. Stone, F. D. McCusig, and R. E. Macherey. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The fuel and blanket elements for the EBR-I, Mark III core loading are round rods nominally 0.403" ± 0.001" diameter by 21.750" long. Both types are identical in external appearance and size. The uranium-bearing section is 19.812" long. This zone is a single section of normal uranium in the blanket rods. Fuel rods contain an 8.500" central section of uranium enriched to 92.5% U^{235} flanked at each end by normal uranium sections. Solid Zircaloy 2 end caps are at the terminal ends of both types. The rods were made of lengths of 2 wt. % uranium–zirconium alloy clad with a 20 mil jacket of Zircaloy 2 by coextruding alloy billets sealed in Zircaloy 2 cans. To circumvent the end effects normally encountered in coextrusion and to minimize the number of billets required, billets of a volume sufficient to provide a number of fuel blanket elements per extruded length were used. The long rods were next cut into shorter lengths appropriate for assembly into either fuel or blanket rods. These were then assembled with the Zircaloy 2 end caps and/or fuel sections and the sections were joined at the jackets by tungsten inert gas welding. To provide mechanical strength to the welded joints, the sections were next bonded throughout the cross section at each joint interface by fusing the uranium alloy to the Zircaloy 2 end fittings and disc separators. Each completed rod is provided with three longitudinal spacing ribs, fastened at 120° intervals around the periphery of the jacket. The ribs, in the form of 0.056" diameter zirconium wire, were automatically spot welded in place, all three ribs being fastened in a single set-up. (auth)

15047 A/CONF.15/P/792
Baltimore Gas and Electric Co., Md. and Atomic Power Development Associates, Inc., Detroit.
DEVELOPMENT OF CORE ELEMENTS FOR THE ENRICO FERMI POWER REACTOR. W. N. McDaniel, O. E. Homeister, and D. O. Leeser. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Various core element binary alloys and configurations have been covered in the core element fabrication development program for the Enrico Fermi Reactor. Alloys of U-Cr, U-Zr and U-Mo were considered. Those with good casting qualities were cast into flat plates, corrugated plates, and even large castings with integral coolant channels. The U-3.5 wt. % Mo alloy was reduced to powder by hydriding and fabricated into flat plates by a powder metallurgy technique. Still others were extruded into small diameter cylindrical rods. In all cases it was difficult to develop the technique to suitably clad the fuel alloy, a necessary requirement in order to reduce the amount of fission gas release to the core coolant and to eliminate mass transport of the uranium alloy. A coextrusion process for fabricating cylindrical rods with the cladding metallurgically bonded to the uranium appeared to be a satisfactory method of obtaining the type of cladding desired. Therefore, this fabrication process was chosen for the core elements. The alloy chosen was U-10 wt. % Mo because of its irradiation stability. (auth)

15048 A/CONF.15/P/925
Los Alamos Scientific Lab., N. Mex.
THE FUEL SYSTEM UO_2–H_3PO_4–H_2O AND LOS ALAMOS POWER REACTOR EXPERIMENT II. B. J. Thamer. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Dilute aqueous reactor fuels have the disadvantage of high vapor pressures at the temperatures desired for power production. The solubility, radiation stability, corrosion, vapor pressure, and thermal expansion of such solutions and the reactor based on one such fuel are discussed. (M.H.R.)

15049 A/CONF.15/P/946
Argonne National Lab., Idaho Falls, Idaho.
WATER CHEMISTRY IN A DIRECT CYCLE BOILING WATER REACTOR. G. K. Whitham and R. R. Smith. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Al alloy cladding for the ceramic thorium-uranium oxide fuel in BORAX-IV requires a rigid and continuous control of pH and water quality through parallel flow ion exchange techniques. The results of

experiments conducted at full power over extended operating periods show that 388-M aluminum alloy is quite satisfactory at 300 psig and 420°F. In conjunction with these studies a considerable effort was devoted to problems associated with the radiolytic decomposition of light water and the subsequent carry-over of decomposition gases with the steam. When the decomposition rate is plotted as a function of reactor power, it approaches a limiting value at about 10 Mw, demonstrating that the specific rate of radiolysis (liters of gas/Mw) decreases with power. Companion experiments holding the pH constant and varying conductivity from 1 to 20 micromhos gave increasing gas rates but not comparable with pH changes, which amount to a 4 to 5 fold increase for a reduction of pH 8 to 4. (auth)

15050 A/CONF.15/P/1016

General Atomic Div., General Dynamics Corp., San Diego, Calif. and Massachusetts Inst. of Tech., Cambridge.

FUEL CYCLES IN SINGLE-REGION THERMAL POWER REACTORS. Thomas H. Pigford, Manson Benedict, Raymond T. Shanstrom, C. C. Loomis, and Bernard Van Ommeslaghe. 80p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An analysis of the fuel cycles for thermal power reactors fueled with natural or slightly enriched uranium or with U^{235}-thorium mixtures is presented. Equations are developed which provide a means of calculating the time variation in reactivity of fuel during its irradiation and of the feed enrichment required and attainable burnup as limited by reactivity lifetime. Numerical examples are given of the changes in composition and reactivity of U^{235}-U^{238} fuel during irradiation, the attainable burnup as a function of the feed enrichment, and the resulting through-put quantities and fuel costs for a pressurized-water reactor and a natural-uranium, heavy-water-moderated reactor. Both batch loading and programmed continuous loading of the make-up fuel are considered, and the examples show the effect of recycle operation on the required feed enrichment and attainable burnups. For recycle operation the required cooling time, through-put through the reprocessing plant, and estimated costs of reprocessing and other recycle conversion operations are given. (auth)

15051 A/CONF.15/P/1017

General Atomics Div., General Dynamics Corp., San Diego, Calif.

DESIGN OF A 10-KW REACTOR FOR ISOTOPE PRODUCTION, RESEARCH, AND TRAINING PURPOSES. Stanley L. Koutz, T. [B]. Taylor, A. McReynolds, F. J. Dyson, and Robert B. Duffield. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Details of the reactor construction are presented. The core of the reactor is a right circular cylinder consisting of a lattice of cylindrical fuel elements in water. The active part of each fuel element is 1.4 in. in diameter and 14 in. long and is made of a homogeneous mixture of hydrided uranium–zirconium alloy containing 8 wt. % of uranium enriched to 20% in U^{235}. The hydrogen-to-zirconium atomic ratio is approximately one. Each fuel element is jacketed with aluminum. Spacing of the fuel elements is such that approximately 35% of the core volume is occupied by water. Cooling of the core is provided by natural circulation of water. The core is located inside a cylindrical graphite reflector of approximately 1 ft in thickness. Several facilities are provided for production of radioactive isotopes. The largest of these is a rotary specimen rack located in the reflector which provides space for the simultaneous irradiation of 40 samples of material. (auth)

15052 A/CONF.15/P/1019

Argonne National Lab., Lemont, Ill.

THE ARGONAUT REACTOR: A GENERALIZED REACTOR FACILITY FOR NUCLEAR TECHNOLOGY TRAINING AND RESEARCH. D. H. Lennox, B. I. Spinrad, C. N. Kelber, R. H. Armstrong, and W. L. Kolb. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Argonaut is a 10-kw (max.) thermal reactor moderated by water and reflected by graphite. It is a flexible, low-cost facility designed primarily for instruction and research in reactor technology. Plate-type fuel elements are spaced with graphite wedges to form an annular core; thus various fuel patterns, from pseudo-slab to multiple groups, can be effected. With 20% enriched fuel, the nominal critical mass is 3.6 kg U^{235} in a double slab configuration. A graphite column within the fuel ring provides a large (2 ft OD by 4 ft high) region for internal exponentials, danger coefficient, and irradiation experiments. Surrounding the core region is a graphite reflector extended on one side to form a thermal column (5 ft square cross section). A movable tank for shielding or migration measurements faces one of the reflector sides. Stacked concrete block constitutes the main body of shield, so that tunnels for large experiments or a second thermal column can be provided. The nuclear characteristics of Argonaut make it self-limiting in the BORAX manner. Measurements show the void and temperature coefficients to be negative: -0.25% k per void %, and -2×10^{-4} k°C, respectively. The measured neutron lifetime is 220 μ sec. Routine control is by insertion of poison rods. Secondary safety is available through removal, and nitrogen injection to reduce moderator density. Total cost for construction of the reactor was ~$100,000. A 20-minute color film showing design details and student participation in experimental uses is available. (auth)

15053 A/CONF.15/P/1028

Ballistic Research Labs., Aberdeen Proving Ground, Md.

SCALE MODEL TESTS FOR EVALUATING OUTER CONTAINMENT STRUCTURES FOR NUCLEAR REACTORS. Wilfred E. Baker. 16p. $0.50(OTS).

Prepared for the Second U. S. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Tests of a carefully instrumented model of the reactor and its containment structure are presented in considerable detail. Laws of scaling of explosive loading, and of structural response, on which this method is based, are presented. The first experiments reported were a series of simulated power excursions conducted within a one-quarter scale model of an actual test reactor. Propellants and explosives were used to simulate the excursions. The response of a homologous series of scaled reactor containment shells to simulated reactor runaway are also reported. A discussion of the test results and recommendations for further analytical and experimental work applicable to design of reactor containment structures is presented. (auth)

15054 A/CONF.15/P/1034

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

THE OPERATING CHARACTERISTICS OF THE MTR ON SPECIAL CORES. D. E. deBoisblanc and R. S. Marsden. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The operating characteristics of the Materials Testing Reactor with a 20% enriched uranium core and with a plutonium core have been compared with those of the standard 93% enriched uranium core. A series of reactor physics and engineering tests has been made on each core. This was followed by operation at 30 megawatts, the full design power of the MTR. (auth)

15055 A/CONF.15/P/1038

Westinghouse Electric Corp. Atomic Power Dept., Pittsburgh; Yankee Atomic Electric Co., Boston; and Stone and Webster Engineering Corp., Boston.

THE YANKEE ATOMIC ELECTRIC PLANT. W. E. Shoupp, R. J. Coe, and W. C. Woodman. 35p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Yankee Plant is presently under construction in New England. It is designed as a 134 Mwe utility plant and will be connected to an existing electrical network. The nuclear steam generator and especially novel aspects of the reactor and connecting systems are discussed. The Yankee reactor is a water cooled, water moderated, low enrichment, stainless clad unit controlled with silver cadmium rods. In order to provide sufficient negative reactivity to permit cooling down the reactor if necessary, provision is also made for introduction of neutron absorbing chemical compounds. The plant location and significant local controlling conditions are discussed. The physical arrangement of the plant is described. The main coolant loops consisting of pumps, steam generators, valves and piping are described. The vapor container and arrangement of equipment within the container are discussed. Necessary auxiliary systems are described. Equipment for the nuclear steam generator is also descirbed. This includes the reactor vessel, steam generators, core, control rod drive mechanisms, etc. A discussion of the planned schedule and expected costs is included. (auth)

15056 A/CONF.15/P/1041

Pennsylvania State Univ., University Park.

RESEARCH AND TEACHING WITH A UNIVERSITY-OWNED RESEARCH REACTOR. R. G. Cochran and F. J. Remick. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Uses made of the Pennsylvania Research Reactor in research and education are listed to show the economic feasibility and usefulness of a university-owned reactor. (M.H.R.)

15057 A/CONF.15/P/1044

American-Standard. Atomic Energy Div., Mountain View, Calif.

FUEL CYCLES FOR NUCLEAR POWER REACTORS. D. P. Herron, D. R. Mash, and J. W. Webster. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A number of possible fuel cycles are appraised, both in their present status and as they may be expected to develop in the future, to determine which of these cycles show the most economic promise. Three principal fuel cycles are evaluated: the $U^{235}-U^{238}$ fuel cycle, with several methods of recycling the plutonium; the $U^{235}-U^{238}$ fuel cycle, with sale of plutonium produced; and the $Th-U^{233}$ fuel cycle, with recycle of U^{233}. General flow sheets are given with unit costs and yields for each step. Graphs and tables are presented on such economic aspects as: fabrication costs, effect of fuel cycle costs on power costs, and the effect of separative work cost on burnup cost. (M.H.R.)

15058 A/CONF.15/P/1047

Los Alamos Scientific Lab., N. Mex.

THE USE OF LOS ALAMOS CRITICAL ASSEMBLY FACILITIES IN A NUCLEAR TRAINING PROGRAM. Glen A. Graves, Gordon E. Hansen, and David P. Wood. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The philosophy, present experiments, and experimental capabilities of the nuclear training course are discussed with emphasis on the use of critical assemblies in laboratory experiments. Photographs of Godiva II, Hydro, Flat-Top, and Planet are included. (M.H.R.)

15059 A/CONF.15/P/1068

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

THE COMPARATIVE ECONOMICS OF PLUTONIUM FUEL UTILIZATION AND U-235 FUEL UTILIZATION IN THERMAL POWER REACTORS. E. A. Eschbach, D. P. Granquist, and Milton Lewis. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Fuel costs are estimated for nuclear power reactors using either plutonium or U^{235} fuels. Minimum costs in a wide range of reactor types and sizes are compared for each of the two fuel systems. Based upon the present pricing schedule for enriched uranium, and upon the achievement of research and development goals, plutonium may have a significant positive value as fuel for thermal reactors. It is anticipated that this value can be maintained, even for highly exposed plutonium, in properly designed reactors. (auth)

15060 A/CONF.15/P/1074

Oak Ridge National Lab., Tenn.

EXPERIMENTS ON THE RELEASE OF FISSION PRODUCTS FROM MOLTEN REACTOR FUELS. George W. Parker and George E. Creek. 14p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Revision of p.32-43, TID-7549(Pt.II).

Since it is possible to simulate such an event on a small scale and to measure the percentage release of each of the fission elements, an investigation of the behavior of several reactor fuels was conducted. At trace concentration of fission products, slow melting of the APPR plate at 1525°C in air or steam effected the release of 50% of the rare gases, 33% of the iodine, 9% of the cesium, and traces of strontium. After 25% burn-up, the cesium value increased to about 60%. Aluminum alloy of the MTR type, also at trace fission-product concentration, upon melting at 700°C released up to 2% of the iodine, 10% of the rare gases, and negligible portions of other fission products. Zirconium alloy of the STR type after 15% burn-up, when melted at 1850°C, released up to 95% of the rare gases, 90% of the cesium, 60% of the iodine, and only a trace of strontium. From these results, it may be inferred that the percentage release of fission products to the atmosphere from molten reactor fuel is proportional to the melting temperature and is affected mainly by the degree of oxidation, the concentration of fission products, and the type of fuel. (M.H.R.)

15061 A/CONF.15/P/1075
Division of Reactor Development, AEC and Argonne National Lab., Lemont, Ill.
EXPERIENCE WITH U. S. NUCLEAR POWER REACTORS. Clark Goodman, Louis H. Roddis, Jr., and W. H. Zinn. 63p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The time table and operating histories of all of the existing nuclear power plants and experimental power reactors in the United States are presented in tabular form. The long operating experience of the U. S. in a variety of power producing reactors, with special emphasis on the water systems and on the use of enriched fuels is summarized. A total of more than twenty reactors is covered ranging in size from the small Los Alamos Fast Breeder Reactor with no electrical power output, which started operating at temperatures useful for possible power production in 1946, to the first full-scale nuclear power plant designed as a commercial installation, the Shippingport Pressurized Water Reactor, which operated at 60 Mwe output in December 1957. Where appropriate, economic considerations are included. (auth)

15062 A/CONF.15/P/1077
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
SOME CORROSION CONSIDERATIONS OF HIGH TEMPERATURE GAS-COOLED REACTORS. S. J. Yosim, R. L. McKisson, A. M. Saul, and D. E. McKenzie. 11p. $0.50(OTS).

Prepared for the Second U. S. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The basic chemical principles by which the corrosion properties and thus the temperature limitations of refractory materials may be evaluated are described. High-temperature corrosion by direct vaporization and the reaction of a gaseous component with the solid to form a gaseous product are considered. (W.D.M.)

15063 A/CONF.15/P/1078
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
FUEL ENRICHMENT AND REACTOR PERFORMANCE. Chauncey Starr. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Specific data and typical examples are presented concerning the effect of enrichment on reactivity, on the cost of power, on the maximum permissible exposure, on the cost of fuel as metal and oxide, and as related to the cost of burnup and power. The chemical reprocessing of the fuel is examined with reference to the effect of plutonium credit. The cost of reprocessed fuel is compared with that of once-through discarded fuel. The conditions under which chemical reprocessing will be economically desirable are established with specific reference to natural uranium as well as enriched fuels. The use of plutonium recycle as a substitute for U^{235} enrichment is quantitatively examined and evaluated. No attempt is made to establish the superiority of either enriched or natural uranium reactors. The interrelationship of costs, fuel cycle characteristics, and nuclear performance are discussed, and their influence on the optimization of the economics of power production is indicated. (auth)

15064 A/CONF.15/P/1079
Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.
EXPERIMENTAL STUDIES ON THE KINETIC BEHAVIOR OF WATER BOILER TYPE REACTORS. M. E. Remley, J. W. Flora, D. L. Hetrick, D. R. Muller, E. L. Gardner, R. E. Wimmer, R. K. Stitt, and D. P. Gamble. 24p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The KEWB Program is devoted to the study of the dynamic behavior of homogeneous type research reactors. The objectives of this program include studies to develop better and more complete understanding of phenomena which contribute to the kinetic behavior and the inherent safety of the water boiler reactor. The approach to the objectives has been to construct a prototype 50 kw homogeneous reactor with the necessary auxiliary apparatus and to study the transient behavior of the system as a function of the more significant parameters which affect this behavior. These include the amount of reactivity release, rate of reactivity release, initial core pressure, initial core temperature, initial reactor power, and void volume above the core. Data are plotted. (auth)

15065 A/CONF.15/P/1080
Atomics International Div., North American Aviation Inc., Canoga Park, Calif.
INTEGRAL SAFETY DEVICES FOR REACTORS. S. H. Fitch, N. E. Huston, N. C. Miller, and A. J. Saur. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The history of the safety device program and its accomplishments to date are described. Safety devices discussed are divided into those for production reactors, research reactors, and low power research reactors and zero power critical assemblies. Sketches of each type are included. (M.H.R.)

15066 A/CONF.15/P/1082
Washington, Univ., Seattle.
GRAPHITE-NATURAL URANIUM SUBCRITICAL REACTOR SYSTEMS FOR EDUCATION AND RESEARCH. W. E. Wilson, L. Grimsrud, and A. L. Babb. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The University of Washington Subcritical Reactor is briefly described. Experiments performed in the instructional program are described, and typical data are presented. (M.H.R.)

15067 A/CONF.15/P/1543
Atomics International Div., North American Aviation Inc., Canoga Park, Calif.
AQUEOUS HOMOGENEOUS TYPE RESEARCH REACTORS. R. F. Wilson, J. O. Henrie, W. N. McElroy, W. E. Parkins, and J. W. Flora. 38p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The solution-type research reactors placed in operation by Atomics International fall into three power range categories. The 50-kw type has the advantages of a large graphite reflector, both horizontal and vertical thermal columns, and gamma ray exposure facilities in its sub-pile area. The 1.5-kw reactor has a $5\frac{1}{2}$-foot square vertical thermal column for exponential work. The 10 watt unit is intended as a training and minimum research facility. These reactors and their operating characteristics are described. (M.H.R.)

15068 A/CONF.15/P/1547
Argonne National Lab., Lemont, Ill.
ZPR-IV' – A VERSATILE SOURCE OF NEUTRONS.

F. C. Beyer, R. C. Doerner, and F. H. Martens. 7p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The ZPR-IV' is a low power reactor consisting of an MTR core placed against an aluminum leakage face in one side of a water tank (8 × 6 × 5 ft). Neutrons leaking from this face are used for experimentation. This reactor, its physical plant, instrumentation, controls, and program are described. (M.H.R.)

15069 A/CONF.15/P/1549
Argonne National Lab., Lemont, Ill.
THE RADIOCHEMICAL ANALYSIS ON THE EBR-I FUEL ASSEMBLY MELTDOWN. R. F. Buchanan. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

This analysis was undertaken to determine the mechanism of the meltdown in the fuel element core of the Experimental Breeder Reactor-I (EBR-I). The conclusions are limited to those based on the results of these analyses. Selected samples from the meltdown area were analyzed for uranium, iron, potassium, cerium-144, plutonium-238, and for plutonium and uranium mass. The chemistry involved in these determinations is reported and a diagram of the sampling in the meltdown area is shown. The chemical and mass spectrographic analyses indicate that there was very little mixing in the core as a result of the meltdown and that the fuel alloy which penetrated the blanket sections originated from the outer part of the molten zone. (auth)

15070 A/CONF.15/P/1551
Advisory Committee on Reactor Safeguards, AEC.
THE EXPERIENCE IN THE UNITED STATES WITH REACTOR OPERATION AND REACTOR SAFEGUARDS. C. Rogers McCullough. 24p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Reactors are operating or planned at locations in the United States in cities, near cities, and at remote locations. There is a general pattern that the higher power reactors are not in, but fairly near cities, and the testing reactors for more hazardous experiments are at remote locations. A great deal has been done on the theoretical and experimental study of important features of reactor design. The metal-water reaction is still a theoretical possibility but tests of fuel element burnout under conditions approaching reactor operation gave no reaction. It appears that nucleate boiling does not necessarily result in steam blanketing and fuel melting. Much attention is being given to the calculation of core kinetics but it is being found that temperature, power, and void coefficients cannot be calculated with accuracy and experiments are required. Some surprises are found giving positive localized void coefficients. Possible oscillatory behavior of reactors is being given careful study. No dangerous oscillations have been found in operating reactors but oscillations have appeared in experiments. The design of control and safety systems varies with different constructors. The relation of control to the kinetic behavior of the reactor is being studied. The importance of sensing element locations in order to know actual local reactor power level is being recognized. The time constants of instrumentation as related to reactor kinetics are being studied. Pressure vessels for reactors are being designed and manufactured. Many of these are beyond any previous experience. The stress problem is being given careful study. The effect of radiation is being studied experimentally. The stress problems of piping and pressure vessels is a difficult design problem being met successfully in reactor plants. The proper organization and procedure for operation of reactors is being evolved for research, testing, and power reactors. The importance of written standards and instructions for both normal and abnormal operating conditions is recognized. Confinement of radioactive materials either by tight steel shells, tight buildings, or semi-tight structures vented through filters is considered necessary in the United States. A discussion will be given of specifications, construction, and testing of these structures. The need for emergency plans has been stressed by recent experiences in radioactive releases. The problems of such plans to cover all grades of accidents will be discussed. The theoretical consequences of releases of radioactive materials have been studied and these results will be compared with actual experience. The problem of exposures from normal and abnormal operation of reactors is a problem of design and operation on one hand and the amount of damage to be expected on the other. The safeguard problem is closely related to the acceptable doses of radioactivity which the ICRP recommend. The future of atomic energy depends upon adequate safeguards and economical design and operation. Accepted criteria are required to guide designers as to the proper balance of caution and boldness. (auth)

15071 A/CONF.15/P/1766
[Illinois Inst. of Tech.], Chicago. Armour Research Foundation.
OPERATIONAL CHARACTERISTICS OF THE ARMOUR FISSION GAS GAMMA FACILITY. C. W. Terrell and W. N. McElroy. 21p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

As the reactor power level is changed frequently, the radiation levels in the gamma facility fluctuate. Data are presented to show the power dependency of the gamma dose rate and the manner of growth and decay. Additional data show the dependency of the equilibrium gamma activity on the fuel temperature and total system pressure. The final phase of the work is directed toward determining an average gamma energy by attenuation measurements with various thicknesses of several materials. The neutron flux associated with the gas phase activity is determined by foil measurement. From the measurements of dose rate and average gamma energy, calculations to determine the number of curies of gas phase decay gamma activity per watt of reactor power are presented. (auth)

15072 A/CONF.15/P/1777
Knolls Atomic Power Lab., Schenectady, N. Y. and Argonne National Lab., Lemont, Ill.
MEASUREMENT OF DOPPLER TEMPERATURE COEFFICIENT IN INTERMEDIATE AND FAST ASSEMBLIES. R. T. Frost, W. Y. Kato, and D. K. Butler. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Measurements made of the Doppler temperature effect for material samples in intermediate and fast spectrum reactors and the experimental technique applied are described. The materials studied in the Be-moderated intermediate reactors were highly enriched U^{235}, U^{238}, and Hf. In the fast reactors, constructed alternatively of highly enriched U and Al or Pu and Al, experiments were performed with samples of enriched and natural U and Pu. Because of the extremely small magnitudes of the Doppler coefficient in the fast spectrum, only upper

bounds could be measured for the effect in the latter experiments. (M.H.R.)

15073 A/CONF.15/P/1782

Argonne National Lab., Lemont, Ill.

CONSTRUCTION DESIGN OF EBR-II: AN INTEGRATED UNMODERATED NUCLEAR POWER PLANT. L. J. Koch, H. O. Monson, W. R. Simmons, M. Levenson, F. Verber, E. Hutter, R. A. Jaross, T. R. Spalding, J. R. Simanton, and A. Lovoff. 43p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Argonne Experimental Breeder Reactor-II is a completely integrated nuclear power plant which employs an unmoderated reactor as a heat source, and generates 20,000 kw of electricity. The integrated nuclear plant includes the fuel re-processing and fabrication cycle and thereby makes a significant contribution to power reactor technology by operating on recycled fuel. The preliminary design of this plant was described at the First International Conference on the Peaceful Uses of Atomic Energy in 1955. Although the basic design concept and objectives have remained unchanged, many modifications have been made in the detailed design, including separation of the facility into several plants and providing containment for the reactor system. The plant capacity and basic power cycle have remained essentially unchanged: 62.5 Mw thermal, 900F reactor sodium outlet temperature, and 1250-psig steam at 850F at the turbine throttle. The feed-water temperature, however, has been increased to 550F to reduce thermal stresses in the steam generator. (auth)

15074 A/CONF.15/P/1783

California. Univ., Livermore. Radiation Lab.; Knolls Atomic Power Lab., Schenectady, N. Y.; Michigan. Univ., Ann Arbor; and Argonne National Lab., Lemont, Ill.

DETERMINATION OF PROMPT NEUTRON DECAY CONSTANTS OF MULTIPLYING SYSTEMS.

J. Bengston, J. E. Carothers, F. A. Kloverstrom, T. T. Komoto, L. Passell, B. E. Simmons, L. S. Bohl, W. K. Luckow, S. W. Churchill, G. S. Brunson, S. G. Kaufmann, and J. P. McMahon. 20p. UCRL-5159(Rev.) $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In a multiplying system below prompt critical, the neutron population in the absence of delayed prompt neutron precursors would decay as $e^{-\alpha t}$ after a normal mode was established, where α is the prompt neutron decay constant. This constant was measured by three different techniques: the pulsed neutron method, the Rossi alpha method, and a related method originally devised by Feynman to measure the mean square number of neutrons emitted per thermal fission. (M.H.R.)

15075 A/CONF.15/P/1838

Oak Ridge National Lab. Tenn.

RADIATION LIMITATIONS ON RECYCLE OF POWER REACTOR FUELS. E. D. Arnold. 33p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The buildup of isotopic contaminants during successive irradiations can greatly affect the handling techniques associated with the recycle of power reactor fuels. The three methods of refabrication considered are direct, semi-remote, and remote. Radiation hazards for U^{233}, Th, U^{235}, normal uranium, and Pu are enumerated. (W.D.M.)

15076 A/CONF.15/P/1841

Brookhaven National Lab., Upton, N. Y.; Westinghouse Electric Corp. Bettis Atomic Power Div., Pittsburgh; and Combustion Engineering Corp., New York.

PHYSICS OF SLIGHTLY ENRICHED, NORMAL WATER LATTICES (THEORY AND EXPERIMENT). H. Kouts, R. Sher, J. R. Brown, D. Klein, S. Stein, R. L. Hellens, and H. Arnold. 70p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Measurements made with water moderated lattices of slightly enriched uranium rods since the last Geneva conference are presented and discussed. Additional measurements on assemblies having uranium oxide as the fuel are also presented. Improvements in technique are described and analyzed. The evolution of theoretical methods of interpreting and predicting the neutron behavior of reactor cores of this kind is recounted. The best present ways of analyzing the neutron economy and criticality are described and discussed, and comparisons with the available data are given. The methods range from multigroup treatments based on homogenization to a few group treatments which may be carried out by desk calculator methods. The derivation of the few group parameters from multigroup results is described. The theoretical treatments are supplemented by comparisons with the older four-factor methods. Finally, some measurements obtained with plutonium enriched rods are described, and tentative results are given. (auth)

15077 A/CONF.15/P/1842

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho. and Westinghouse Electric Corp. Bettis Plant, Pittsburgh.

THE REACTIVITY MEASUREMENT FACILITY AND ITS APPLICATIONS. D. R. DeBoisblanc, J. C. Connor, E. Fast, S. B. Gunst, G. R. Hopkins, and C. P. Jamieson. 23p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The design and description of the Reactivity Measurement Facility, a low-power reactor located in the fuel element storage canal of the Materials Testing Reactor, are discussed. The types of experiments unique to the RMF-MTR combination are the measurement of long-term reactivity gains with small samples, the measurement of short-lived radiation produced poisons, and non-destructive measurements of fuel and fission product poisons. (W.D.M.)

15078 A/CONF.15/P/1843

Westinghouse Electric Corp. Bettis Plant, Pittsburgh. and Knolls Atomic Power Lab., Schenectady, N. Y.

THE ROLE OF DIGITAL COMPUTERS IN THE DESIGN OF WATER MODERATED REACTORS. E. M. Gelbard, G. J. Habetler, and R. Ehrlich. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The preparation of parameters used in few-group codes is discussed. Machine codes and special devices used to solve one- and multi-dimensional reactor problems within the framework of a few-group diffusion theory are described. Control rod and transport problems are treated. A discussion of the accuracy of present computing methods and an assessment of major computing problems which may be encountered in the near future is given. Inherent code limitations and typical machine times for individual codes referred to are included in an appendix. (M.H.R.)

15079 A/CONF.15/P/1845
Argonne National Lab., Lemont, Ill.
STABILITY STUDIES ON EBR-I. F. W. Thalgott, J. F. Boland, R. O. Brittan, J. C. Carter, F. D. McGinnis, M. Novick, D. Okrent, H. A. Sandmeier, R. R. Smith, and R. E. Rice. 25p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

During this period of operation as a small power reactor and irradiation-test facility, two dynamic characteristics were observed which required further study. One of these, the power response to sudden changes in coolant flow, indicated the presence of a prompt positive power reactivity coefficient, this coefficient being overcome by a slower negative coefficient to produce an over-all negative effect. The second phenomena was observed at power-to-coolant flow ratios greater than the design ratio. Oscillations in power occurred which became more severe as power was increased or coolant flow decreased. A complete description of the kinetic behavior of the EBR-I is given. (auth)

15080 A/CONF.15/P/1848
Argonne National Lab., Lemont, Ill.
TREAT, A PULSED GRAPHITE MODERATED REACTOR FOR KINETIC EXPERIMENTS. G. A. Freund, H. P. Iskenderian, and D. Okrent. 33p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

TREAT or Transient Reactor Test Facility is being constructed by Argonne National Laboratory to generate safely a large, transient, thermal flux (over 10^{15} neutrons/cm^2) of short duration. This flux is an order of magnitude greater than that produced in the final transient of Borax-I and will be sufficient to permit meltdown studies on mockups of fast reactor fuel elements. The practical engineering and physics design of TREAT is discussed. Attention is given the choice of cladding material, the form of the fuel element, the size of the reactor core, and the type of control rod. (M.H.R.)

15081 A/CONF.15/P/1850
Atomic Power Development Associates, Inc., Detroit; Power Reactor Development Co., Detroit; and Detroit Edison Co., Detroit.
ENRICO FERMI ATOMIC POWER PLANT. Alton P. Donnell, Robert W. Hartwell, and Harvey A. Wagner. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The fast breeder reactor designed and developed during the past six years is being installed in the Enrico Fermi Atomic Power Plant. This plant is being constructed by the Power Reactor Development Company and the Detroit Edison Company under the Atomic Energy Commission power demonstration reactor program. On the basis of work done to date, the breeder reactor continues to be a promising type for the eventual development of electric power from nuclear fission on a commercially feasible basis. Construction is in progress pursuant to a permit issued by the AEC. The reactor, a full-scale developmental fast breeder, with a design rating of 300 Mw and 100 Mw, is being built on land leased from the Detroit Edison Company. The latter will construct, own, and operate adjacent turbine generating facilities and will purchase the steam required for those facilities from Power Reactor Development Company. Design work on the nuclear and nonnuclear portions of the plant is well advanced. (A.C.)

15082 A/CONF.15/P/1858
Argonne National Lab., Lemont, Ill.
THEORY OF COUPLED REACTORS. R. Avery. 25p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The system of coupled reactors is described in terms of integral parameters which explicitly characterize the individual reactors and the coupling between them. The system is defined by any prescription which specifies in which assembly each fission neutron is liberated. This, in general, will be a spatial division and/or a division according to the energy of the neutron which caused the fission. The entire system is then characterized by certain integral parameters: k_{ij} defined as the expectation value that a fission neutron in assembly i will give rise to a next generation fission neutron in assembly j; and l_{ij}, the average prompt neutron lifetime for the process. These parameters must be properly averaged with weighting factors involving the adjoint function in order to obtain internal consistency with the general reactor equations. (auth)

15083 A/CONF.15/P/1869
General Electric Co. Hanford Atomic Products Operation, Richland, Wash.
GENERALIZED DIFFUSION THEORY METHODS FOR REACTOR SURVEY APPLICATIONS. John R. Triplett. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Fourier transform of the kernel for the one-velocity isotropic-scattering transport equation is represented by a quadratic rational approximation:

$$G(\underline{k}) = \frac{\tan^{-1} k\lambda}{k\lambda} \rightarrow \frac{1 + A\lambda^2 k^2}{1 + B\lambda^2 k^2}$$

which leads to a second-order differential equation in co-ordinate space. The constants A, B, and λ may be assigned different values in different spatial regions; further, A and B may or may not depend parametrically upon the mean number of secondaries per collision. The treatment of sources and boundary conditions, theorems relating the constants A and B to moments, diffusion lengths, etc. and the numerical comparison of results for standard problems are described. Advantages of this approach include greater adaptability to variation of design parameters over extreme range, and more realistic treatment of boundary conditions, than is possible with the usual versions of diffusion theory. Applications to survey codes and multigroup calculations are discussed, and results are presented to illustrate the method. Relative advantages of this approach and the double spherical harmonics method are described. (auth)

15084 A/CONF.15/P/1873
[Westinghouse Electric Corp. Atomic Power Div.], Pittsburgh.
PRODUCTION OF RADIOISOTOPES IN TESTING REACTORS. E. T. Morris, Jr. and M. A. Schultz. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

It is shown that testing reactors have large capacities for handling many experiments or specimens, but in the event all of the facilities are not filled up by the irradiation experiments, there exists the possibility of using the empty spaces to produce isotopes and thus always operate the reactor at full capacity. A method for calcu-

lating the effects of isotope samples on neighboring tests is presented and it is shown that a total cross section limitation must be imposed upon each isotope sample in order not to cause adjacent flux depressions. A curve indicating the differences in permissible poison as a function of specimen location is presented. From a summation of the permitted cross sections over the core and reflector the total number of curies of activity that can be produced in a given testing reactor operating at a fixed average flux over a given time interval is derived. A method is postulated to calculate the cost of producing isotopes on a dollar per curie basis as a function of both half-life and irradiation time. Specific examples of the production of a number of isotopes in a testing reactor are presented, using the geometry and constants of the Westinghouse Test Reactor for illustration. Production of Co^{60} and Ir^{192} is presented in detail and the effects of present-day specific activity requirements upon costs are examined. The results indicate the manner in which production costs rise with half-life and comparisons are made with current U.S. selling prices for various (n,γ) produced isotopes. It appears that most isotopes can be produced economically in a testing reactor, but some long half-lived isotopes such as Co^{60} and tritium do not fit the derived cost structure. (auth)

15085 A/CONF.15/P/1878

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

PERFORMANCE OF METALS DURING SIX YEARS SERVICE IN THE MATERIALS TESTING REACTOR. M. H. Bartz. 23p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The performance of metals during six years service in the MTR is summarized for structural components, fuel elements, control rods, high pressure piping, and pressure vessels in high radiation fields. It is concluded that not a single failure of equipment can be attributed solely to the effects of radiation changing the properties of the metals used in its structural and fuel components. (M.H.R.)

15086 A/CONF.15/P/1879

Stone and Webster Engineering Corp., Boston.

VAPOR CONTAINERS FOR NUCLEAR POWER PLANTS. C. T. Chave and O. P. Balestracci. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A survey of containers used for domestic and foreign nuclear plants of larger than 1 Mw is presented. In general, all U. S. reactors of significant power level have been installed in steel containment shells, unless elimination can be justified by favorable location or inherently safe conditions of pressure and chemical reactivity. The designer must consider the maximum credible accident, including the container pressure rise and the effect of missiles created by the incident. Important factors are the container material and configuration, the merits of location above or below grade in whole or in part, the use of a single shell as opposed to multiple innerconnected shells and provisions for missile protection with linings or with detached structures. Experience with the Shippingport, APPR, and Yankee containers indicates that for pressurized water reactor plants optimum choices are detached structures for missile protection, steel container material, cylindrical shape and above-grade container installation. These factors are discussed and evaluated for plants of other types. (auth)

15087 A/CONF.15/P/1884

Aerojet-General Nucleonics, San Ramon, Calif.

SAFETY ASPECTS OF HETEROGENEOUS COMPACT GAS-COOLED REACTORS. D. R. Sawle and F. J. Thomas. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Various aspects of compact gas-cooled reactors are considered. The maximum conceivable accidents for various designs, as well as hazards from less severe accidents, and the probability of accident occurrence are discussed. (J.E.D.)

15088 A/CONF.15/P/1885

Consolidated Edison Co. of New York, Inc.; Vitro Engineering Co., New York; and Babcock and Wilcox Co., New York.

THE CONSOLIDATED EDISON COMPANY OF NEW YORK NUCLEAR ELECTRIC GENERATING STATION. G. R. Milne, F. R. Ward, and S. M. Stoller. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Consolidated Edison Company of New York is erecting a nuclear steam electric generating station at Indian Point on the Hudson River 24 miles north of New York City. The initial station capacity is estimated at about 236 megawatts of which 140 Mw would be developed by the reactor and 96 Mw in two separate oil fired superheaters. The ultimate station capacity expected is 275 Mw. The costs of nuclear generation with and without superheating are discussed and the corresponding thermal efficiencies are given. The principal components of both the nuclear and conventional portions of the plant are described. The reactor will be a pressurized water, internal converter type unit and will be the first commercial reactor to use thorium as the fertile material to supplement the base fuel highly enriched U^{235}. The present status of the development, design, manufacturing, and construction work is reviewed. Initial operation of the station is presently planned for December 1960. (auth)

15089 A/CONF.15/P/1891

Argonne National Lab., Lemont, Ill.

CONTAINMENT FOR THE EBWR. A. H. Heineman and L. W. Fromm. 28p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Containment for a boiling water reactor comprises a basic gas-tight vessel, and the means by which this integrity is maintained in event of the most disastrous incident assumable. The many factors which must be considered in developing a design are presented. These include: economics and space requirements; external and internal pressures involved; corrosion protection; insulation; missile protection; means for preventing launching of potential missiles; materials of construction; and quality control for materials and construction. The philosophy and limitations for establishment of design parameters are presented together with an exposition of the processes used to resolve the various problems. Determination of vessel dimensions and design pressure, and the arrangement of the various plate components are explained. The decision to base the maximum foreseeable pressurization on a 25% core metal-water reaction is developed. Vessel design based on the ASME Code, Section VIII, welded construction, also steel plant material selected with specifications covering its manufacture, are described. Requirements of 10% spot-test radiography, chiefly at weld

junctures, was specified. Vessel construction, also soap solution, pressure strength, and leakage rate tests and instrumentation involved are described, and reasoning in arriving at allowable leakage rates is given. (auth)

15090 A/CONF.15/P/1892

Argonne National Lab., Lemont, Ill. and Illinois Inst. of Tech., Chicago. Armour Research Foundation.

CONTAINMENT OF EBR-II. H. O. Monson and M. M. Sluyter. 33p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Experimental Breeder Reactor-II features two systems for containment of fission products and/or plutonium released in the unlikely event of a major nuclear accident. The primary containment system, which surrounds the reactor tank, is designed to contain the effects of a nuclear energy release without breaching. The building containment system, which surrounds both the primary containment and the balance of the reactor plant, serves to localize within the building the effects of a possible sodium-air reaction. The systems are described and evaluated. (auth)

15091 A/CONF.15/P/1893

Argonne National Lab., Lemont, Ill.

SODIUM-AIR REACTIONS AS THEY PERTAIN TO REACTOR SAFETY AND CONTAINMENT. J. R. Humphreys, Jr. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The experimental equipment for this investigation was designed to permit the explosive injection of sodium into a sealed reaction vessel containing air at atmospheric pressure. Resulting temperatures and pressures were measured as a function of time. In all cases, the maximum pressures were less than those theoretically possible. The data indicate a decreasing influence of additional sodium on peak pressures. (W.D.M.)

15092 A/CONF.15/P/1923

General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.

OPERATION OF A HIGH PERFORMANCE LIGHT WATER BOILING REACTOR. E. Beckjord, D. Fischer, M. A. Head, L. K. Holland, L. Kornblith, Jr., S. Untermyer, and L. Welsh. 28p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Vallecitos Boiling Water Reactor is briefly described. The operating experience is summarized under the following subjects: nuclear calculations, initial power loading, startup and operating characteristics, water decomposition, separation factor and residual water activities, neutron flux distribution, and coolant flow and steam voids. The stability of this reactor is discussed. Sketches and photographs of the plant and graphs on the reactor performance and characteristics are presented. (M.H.R.)

15093 A/CONF.15/P/1925

Oak Ridge National Lab., Tenn.

APPR FUEL TECHNOLOGY. J. E. Cunningham and R. J. Beaver. 23p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In the APPR, highly enriched fuel in the form of a refractory oxide is dispersed in a metallic matrix to maximize the heat-transfer surface available for each gram of uranium-235. It is contained in a stainless steel jacket to afford corrosion protection and retain the highly poisonous by-products of fission. The use of a burnout poison to facilitate control and prolong the life of the heavy-investment fuel element is discussed. The technological factors, such as compatibility, corrosion resistance and irradiation effects, which led to the selection of UO_2 as the fuel dispersant, B_4C as the burnout poison, and austenitic stainless steel as the cladding and matrix material, are reviewed. Specifications covering the material, dimensional, thermal and nuclear characteristics of the products are tabulated. The fabrication procedures developed and adopted for manufacturing the fuel component are described. Enriched UO_2 and a small quantity of B_4C are incorporated into the fuel element by powder-metallurgy techniques. The resultant compact, containing 25 wt. % UO_2 and 0.18 wt. % B_4C dispersed in stainless steel powder, is clad with austenitic stainless steel by roll bonding to produce a composite fuel plate of 30-mils over-all thickness and 5-mils cladding on each side. Assembly and processing the thin plates into an integral unit by brazing with a nickel-base alloy are described. The fabrication problems associated with the interaction of B_4C and stainless steel, homogeneity and fragmentation of the oxide particles, sensitization, bond integrity, and the braze-joint design are discussed in detail. Quality-control measures adopted to produce components within dimensional tolerance on a pilot-plant basis are described. This type of dispersion has demonstrated its utility in a 550°F pressurized-water reactor. Its application, however, is not limited to such relatively low temperature reactors. Data are presented on the behavior of this combination under irradiation at temperatures up to 1650°F, along with elevated temperature, physical and mechanical property data. Material selection and fabrication effects become more significant when the UO_2-stainless steel system is considered for higher temperature application, and the important factors are described and evaluated. (auth)

15094 A/CONF.15/P/1926

Alco Products, Inc., Schenectady, N. Y.

DESIGN AND OPERATION OF THE APPR-1. K. Kasschau. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Army Package Power Reactor (APPR-1) has a power output of 10 thermal megawatts producing 2 Mw electricity with a heterogeneous, light water moderated, stainless steel–UO_2 plate-type core as heat source. The design of the major primary system components was influenced to a large extent by factors peculiar to its role as a prototype of power plants suitable for operation in remote areas. Descriptions and specifications of major primary system components and the primary and secondary system heat balance are presented. (auth)

15095 A/CONF.15/P/1929

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

EXPERIENCE IN THE USE OF THE PHYSICAL CONSTANTS TESTING REACTOR. R. E. Heineman. 31p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Physical Constants Testing Reactor is a seven-foot cube of graphite with a large cavity of about 24-cubic-foot volume located at its center. The reactor is made critical by distributing enriched uranium in the graphite on the boundary of the central cavity. A description of the unique engineering and safety features utilized in the design of this reactor are presented. The

null reactivity method for obtaining the infinite medium, thermal neutron multiplication factor, k_∞, is discussed. The relationship of this method to the measurements of material bucklings in exponential columns poisoned with a thermal neutron absorber is described. (auth)

15096 A/CONF.15/P/2010
Florida. Univ., Gainesville.
THE CRITICALITY SIMULATOR AS A TRAINING TOOL. W. F. Fagen. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The College of Engineering at the University of Florida has set up a facility for instruction in nuclear technology comprising a subcritical assembly with special electronic instrumentation which simulates critical operation. Necessary auxiliary instruments for measurement and control are integrated with the system so that engineering instruction can be carried out in a realistic environment. (auth)

15097 A/CONF.15/P/2021
Los Alamos Scientific Lab., N. Mex.
PLUTONIUM FUELS FOR FAST REACTORS. D. B. Hall. 9p. $0.50(OTS).

The problems involved in Pu-based fuels are discussed. Among the fuels covered are Pu–U alloys, PuO_2–UO_2 systems, and Pu–Al intermetallic compounds. Alloys with Bi, Fe, Co, Ni, and Ce are included also. Some attractive reactor concepts are mentioned. (M.R.H.)

15098 A/CONF.15/P/2156
Argonne National Lab., Lemont, Ill.
ANALYSIS OF THE EBR-I CORE MELTDOWN. R. O. Brittan. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An analysis of the nuclear, thermodynamic, and physical behavior of the core was made which yields information on temperature and material disposition which is consistent with observation and measurements on the final state of the core. In particular, it is shown that shutdown of the nuclear reaction occurred as a result of scram action and not as a result of change in reactivity due to physical changes in the core material. The latter could have been a self-limiting action but only with a resulting energy yield inconsistent with the final condition and disposition of the core materials. The data obtained during the experiment makes it possible to determine the power coefficient of reactivity and to estimate temperature coefficients. Estimates made during the time the power level recorder was off-scale yield most probable values of 9000 kw for the peak power level, and 14,000 kw for the total energy release. The corresponding temperature estimates indicate that the peak of about 1100°C occurred after peak power. (auth)

15099 A/CONF.15/P/2160
Argonne National Lab., Lemont, Ill. and Argonne National Lab., Idaho Falls, Idaho.
COUPLED FAST-THERMAL POWER BREEDER CRITICAL EXPERIMENT. R. Avery, C. E. Branyan, G. S. Brunson, C. E. Cohn, G. F. Fischer, H. H. Hummel, W. Y. Kato, F. S. Kirn, D. Meneghetti, F. W. Thalgott, and B. J. Toppel. 34p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A coupled fast-thermal reactor experiment was performed on the Argonne National Laboratory Fast Critical Facility (ZPR-III). These experiments were on a 50-liter core mockup of a power breeder system and concern the critical loading, power distribution, neutron lifetime, subcriticality without thermal fissions, danger coefficients important for a hazards evaluation of the system, and the effectiveness of various control methods. The major advantage over the all-fast system consists of a substantially longer prompt neutron lifetime which is achieved with only a small reduction in breeding ratio. (M.H.R.)

15100 A/CONF.15/P/2162
Oak Ridge National Lab., Tenn.
THE SHIELDING OF NUCLEAR REACTORS. Everitt P. Blizard. 25p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Data and methods now available to the shield designer are summarized, and several new materials recently developed are introduced. (auth)

15101 A/CONF.15/P/2164
General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.
TRAINING OF THE OPERATING STAFF FOR A NUCLEAR POWER PLANT. E. L. Armstrong. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The main items which should be included in a program of training for nuclear power plant operators are outlined. Descriptions of the responsibilities of several staff positions are given. (W.D.M.)

15102 A/CONF.15/P/2165
Argonne National Lab., Lemont, Ill. and Atomic Power Development Associates, Inc., Detroit.
STUDIES OF NUCLEAR ACCIDENTS IN FAST POWER REACTORS. W. J. McCarthy, Jr., R. B. Nicholson, D. Okrent, and V. Z. Jankus. 55p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The essential reactivity characteristics of a fast reactor are presented with discussion of the relative magnitude of the various nuclear, geometric, and density effects as well as their dependence on temperature, time, and the details of the mechanical design. Thermal characteristics of the general type are discussed in regard to their role in temperature-reactivity feed back effects. The types of accidents examined are those initiated by reactivity insertion and initiated by loss of effective cooling. The course of accidents falling in these categories is traced either to termination of the incident or to the point where the fuel in the reactor melts. The role of protective devices in preventing the accidents is discussed, together with the limitations of such devices. Since geometric redistribution of fuel in a fast reactor following melting can in principle cause large reactivity increases, the important features of meltdown are presented, emphasizing the theoretical work under way and discussing possible experiments to aid in this work. The limits of reactivity available in the EBR-II and EFR due to redistribution of fuel are shown together with discussion of the actual fuel distribution found upon examination of the EBR-I Mark II core which melted in November 1955. Since the magnitude of any nuclear energy release caused by meltdown is a function of the rate of assembly of the molten material, limits of this rate are established and several models which have been used in calculation are presented and discussed. Finally the energy release resulting from various meltdown accidents is estimated,

together with a discussion of the major uncertainties involved in such calculations and the parameters upon which the results are most dependent. (auth)

15103 A/CONF.15/P/2167

General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.

RECYCLE OF PLUTONIUM IN LOW-ENRICHMENT LIGHT WATER REACTORS. P. Greebler, W. H. Harker, J. M. Harriman, and E. L. Zebroski. 39p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The recycle of plutonium in low enrichment thermal reactors affords a possible way of reducing or eliminating the requirement for makeup with enriched uranium. Analysis of fuel cycles incorporating plutonium recycle has been made, taking into account the calculation of the isotopic composition and reactivity history of the fuel for realistic reactor configurations, and the evaluation of alternate fuel cycles for reasonable variations in the supply and cost of materials, processing, and fabrication associated with fuel. The light water boiling reactor was studied in detail because many of the alternate fuel cycles available give fuel costs lower than fossil fuel costs, and because the total of fuel, capital and operating costs has good prospects of being attractive under many circumstances. A general model is developed which simultaneously takes into account the shifting neutron spectrum effects, the effect of spatial power variation, and of partial-batch recycling. The model chosen utilizes four collateral resonance groups below 6 ev and a thermal group whose detailed behavior is determined by solution of the Wilkins equation. Application of the model to large light-water boiling reactors is shown, together with a mapping of reactivities and isotopic compositions for varying lattices, enrichments and cycle times. Reactor cases are presented which, even though they may be capable of operating on natural uranium makeup, would normally attain minimum power costs by using recycle plus partial makeup with slightly enriched uranium. (auth)

15104 A/CONF.15/P/2177

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

TECHNICAL AND ECONOMIC ASPECTS OF MTR AND ETR OPERATION. R. L. Doan and J. P. Lyon. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Features of the various loops are described, and a discussion is given of the technical problems encountered in their design and operation, principal among which are the high gamma flux encountered in the MTR and ETR and the radiation effects on in-pile tube structural materials. Information is included on the type of organization required to assure adequate engineering surveillance of in-pile loops from a safety viewpoint as well as the kinds of incidents that have been encountered. Operating costs and utility requirements for the MTR and ETR are presented, together with the economic basis for arriving at the full-cost recovery charge of $55 per irradiation unit of 10^{20} nvt per cubic inch of irradiation space that is in effect at both the MTR and ETR for commercial irradiations. Some economic aspects of the utilization of spent fuel elements in the high intensity (10^7 rep/hr maximum) gamma irradiation of foodstuffs, chemical systems, plastics, etc. are discussed. (auth)

15105 A/CONF.15/P/2291

Argonne National Lab., Lemont, Ill.

SODIUM TECHNOLOGY FOR NUCLEAR POWER PLANTS. F. A. Smith. 30p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Sodium-cooled power reactors will require sodium flow rates through the reactor of 10,000 to 50,000 gpm at pressures up to 100 psi and temperatures up to 1,000°F. The present sodium-cooled reactors are smaller then required for central power plants; however, a program including development of pumps and piping systems, sodium pre-heating methods, instrumentation, heat exchangers, mechanisms and seals, and sodium chemistry has been instituted. A large composite test facility duplicating the salient features of the EBR-II primary sodium reactor system and containing 5,000 gallons of sodium has been in operation since 1955. Further work has been done on sodium purification for higher temperature systems, permitting the use of oxygen sensitive materials. A broad program of investigation has been initiated in the field of heat exchanger design, and several large sodium cooled reactors are under construction which will contribute extensively to the technology of sodium. (J.R.D.)

15106 A/CONF.15/P/2356

Westinghouse Electric Corp., Atomic Power Dept. Pittsburgh.

DESIGN CONSIDERATIONS FOR THE PENNSYLVANIA ADVANCED REACTOR SLURRY HOMOGENEOUS PLANT. W. E. Johnson, S. Bartnoff, D. H. Fax, and E. U. Powell. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The Pennsylvania Advanced Reactor (PAR) is a large (150,000 ekw) aqueous homogeneous reactor for central station use. The scope and details of the reactor and plant are briefly described. A most attractive feature is the promise of low fuel cost. This promise derives from the possibility of a high rate of conversion of fertile into fissionable material without the need for costly fabrication and refabrication of fuel elements. One factor which offsets in part this advantage of low fuel cost is the higher capital cost attributable to a plant arrangement which must allow for remote maintenance of irradiated components and associated piping. Some of the major results in this area are reviewed. (auth)

15107 A/CONF.15/P/2355

Brookhaven National Lab., Upton, New York, and Babcock and Wilcox Co. Atomic Energy Div., Lynchburg, Va.

LIQUID METAL FUEL REACTOR AND LMFRE-I. Clarke Williams and Robert T. Schomer. 28p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An outline of the progress in the Liquid Metal Fuel Reactor program since the last Geneva Conference is presented, along with the results of a number of feasibility and economic evaluation studies on various LMFR designs. Exponential and critical experiments are underway to establish core design parameters. The chemistry research to date indicates that either continuous processing plants or batch processing is feasible for the uranium-bismuth circulating fuel. $2\frac{1}{4}$ Cr-1 Mo has been extensively tested in thermally convected and pumped loops and appears to be a possible container material. Steels with lower chrome or no chrome con-

tent appear to corrode even less. Graphite exposed to bismuth-uranium solution appears to be a satisfactory container material. Studies are underway on slurries both of $ThBi_2$ and ThO_2 in liquid bismuth. Of the various designs considered, the most attractive appears to be a single region reactor in which the fuel mixture of U^{233}-Th-Bi is circulated through an external heat exchanger. A two region reactor with U^{233}-Bi solution fuel circulates through the core and a $ThBi_2$ in liquid bismuth slurry is circulated through a blanket region surrounding the core and separated from it by a graphite burner. (auth)

15108 A/CONF.15/P/2364

General Atomics Div., General Dynamics Corp., San Diego, Calif.

PULSED SOLID HOMOGENEOUS REACTORS FOR RESEARCH. A. W. McReynolds, J. M. Stein, and T. B. Taylor. 27p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A new kind of research reactor is described, which is designed to operate in short pulses of extremely high flux, up to 3.5×10^{17} neutrons/cm^2/sec. General consideration of the principles of design and kinetics of operation shows that the solid homogeneous system, in particular graphite–uranium, is almost uniquely suitable for this purpose. Intimate mixing of the uranium fuel with the graphite moderator gives a core whose large heat capacity, stability under thermal shock, and high allowable temperature rise maximize the pulse size. More important, pulsed operation is made possible because the pulse size is infallibly self-limited by an inherent prompt negative temperature coefficient. The basic physical mechanism is described by which this feature arises from the instantaneous adjustment of neutron temperature to core temperature, without any mass motion. A specific design is presented for a reactor to be pulsed by the insertion of up to 5% excess reactivity by rapid withdrawal of a control rod. The computed characteristics of the resultant pulse are: peak power and flux, 50,000 Mw and 3.5×10^{17} neutrons/cm^2/sec; integrated power and flux, 800 Mw/sec and 6×10^{15} nvt; half-width, 0.013 millisecond; core temperature rise, 500°C. The reactor is then sub-critical by 5% and, with 50-kw average cooling rate, requires about 4 hr cooling before the next pulse. Besides the unusual operating characteristics, it has exceptionally good safety characteristics and simplicity of design, construction, and operation comparable to the lowest-power continuous reactors. (auth)

15109 A/CONF.15/P/2366

Brookhaven National Lab., Upton, New York.

A STATUS REPORT ON THE CONVERSION OF THE BROOKHAVEN GRAPHITE REACTOR TO ENRICHED FUEL. N. Corngold, J. Hendrie, and Robert Powell. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experience to date with the reloaded reactor, with emphasis on critical dimensions, flux distributions, temperature coefficients, and over-all operating experience with the new elements, is discussed. (W.D.M.)

15110 A/CONF.15/P/2372

General Electric Co. [Atomic Power Equipment Dept., San Jose, Calif.]: Commonwealth Edison Co., Chicago; and Bechtel Corp., [San Francisco].

THE DRESDEN NUCLEAR POWER STATION. V. A. Elliott, R. D. Maxson, V. D. Nixon, and J. W. Merryman. 59p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A design description of the Dresden Nuclear Power Station, a 180-Mw all nuclear unit, is presented. The construction, operating phases, and future development for boiling water reactors are discussed. (W.D.M.)

15111 A/CONF.15/P/2373

Westinghouse Electric Corp. Atomic Power Dept., Pittsburgh.

TECHNOLOGY OF AQUEOUS THORIA SLURRIES FOR SINGLE-REGION HOMOGENEOUS REACTORS. W. E. Johnson, D. H. Fax, H. J. Garber, and G. R. Taylor. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The problems associated with transferring and circulating aqueous slurries of thorium oxide at concentrations and conditions appropriate to a single-region homogeneous reactor are defined. The status of the program of the Pennsylvania Advanced Reactor Project is described. (W.D.M.)

15112 ACONF.15/P/2376

Westinghouse Electric Corp., Bettis Plant, Pittsburgh.

THEORETICAL ANALYSIS OF HIGHLY ENRICHED LIGHT WATER MODERATED CRITICAL ASSEMBLIES. M. Goldsmith, R. T. Jones, T. M. Ryan, S. Kaplan, and A. D. Voorhis. 26p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experiments with a series of slab cores composed of highly enriched U^{235}, Zr, and water surrounded by reflectors of either water or a metal-water mixture and their analysis are described. The assemblies are amenable to one-dimensional analyses employing available cross section information and diffusion theory improved in highly absorbing regions by transport theory. In addition to calculation of the respective effective neutron multiplication factors or the critical core dimensions, the analysis includes computation of epithermal and thermal flux shapes and comparison of these with experimental activation traverses of the assemblies. In addition to one-dimensional studies of thermal and resonance neutron absorption, an experiment in which a cruciform Hf control rod was fully inserted in the core was analyzed. The analysis developed was found adequate for the prediction of the eigenvalue of a critical assembly to within 1%. Computed flux distributions agree well with the experimental results. (M.H.R.)

15113 A/CONF.15/P/2378

Argonne National Lab., Lemont, Ill. and General Electric Co., Hanford Products Operation, Richland, Wash.

NEW DEVELOPMENTS IN NONDESTRUCTIVE TESTING OF REACTOR FUEL ELEMENTS. W. J. McGonnagle and R. S. Paul. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The high standard of integrity demanded for nuclear reactor components, especially fuel elements, has resulted in a continuing program for the development of nondestructive testing techniques. Ultrasonic, sonic resonance, eddy current, x-ray and gamma ray techniques are being applied to a variety of problems. This paper reviews some of these new developments and their use in automated testing systems. (auth)

15114 A/CONF.15/P/2379

Argonne National Lab., Lemont, Ill.

PERFORMANCE EVALUATION OF DIRECT CYCLE BOILING WATER NUCLEAR POWER PLANTS BASED

ON RECENT EBWR BORAX DATA. J. M. Harrer, J. A. DeShong, Jr., V. C. Hall, J. A. Thie, W. R. Wallin, E. A. Wimunc, and R. E. Bailey. 49p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Data are given for EBWR-I and BORAX-IV on reactor characteristics, performance, and operation. The performance to date shows that the natural circulation system is capable of advantageously high heat density operation. (W.D.M.)

15115 A/CONF.15/P/2380

Westinghouse Electric Corp. Bettis Atomic Power Div., Pittsburgh.

THE MANUFACTURE OF PWR BLANKET FUEL ELEMENTS CONTAINING HIGH DENSITY URANIUM DIOXIDE. J. Glatter, E. F. Losco, W. J. Hurford, J. S. Theilacker, R. L. Fischer, N. T. Saunders, and R. A. Wolfe. 42p. (WAPD-T-763). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An account is given of the accomplished production of the blanket fuel elements for the first PWR core and of the current status of development on the blanket fuel elements for the second core. High density uranium dioxide cylindrical pellets were utilized in the rod type unbonded fuel element of the first core. Dense uranium dioxide wafers are currently under development for use in a flat plate type unbonded fuel element for the second core. The methods and techniques utilized for fabricating the fuel rod bundles are described in detail. The methods for fabricating the shells and shell assemblies are given in detail. Integrated with the engineering and manufacturing account of each of the blanket fuel element components is a description of the quality evaluation methods used. The manufacturing costs and yields for each of the blanket components for the first core are also presented. A method of fabricating a plate type, dense uranium dioxide bearing fuel element consistent with the realization of desired mechanical rigidity is described. Mechanical properties, corrosion resistance data, and irradiation stability information is presented to illustrate the current evaluation of performance of the flat plate type unbonded fuel element contemplated for use in the second core. (auth)

15116 A/CONF.15/P/2381

Knolls Atomic Power Lab., Schenectady, N. Y.

PHYSICS CONSIDERATIONS IN THE DESIGN OF INTERMEDIATE ENERGY SPECTRUM REACTORS. H. B. Stewart, P. L. Hofmann, and M. L. Storm. 21p. $0.50 OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A short description is given of various critical assemblies pertinent to building high power, intermediate energy, Na-cooled, Be-moderated reactors. Reactivity coefficient measurements in these assemblies are summarized, and the observed spectral dependence of these data is interpreted using perturbation theory formalism. Fission product poisoning data are presented and compared with fission product poisoning in thermal reactors. A qualitative discussion of fuel and control requirements in intermediate energy reactors is given. (M.H.R.)

15117 A/CONF.15/P/2387

Battelle Memorial Inst., Columbus, Ohio.

RESEARCH EXPERIENCE WITH PLASTIC-MODERATED CRITICAL ASSEMBLIES. F. J. Jankowski. 47p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experiments were performed to establish a basis for substituting plastics for liquids. In one of these reactivity coefficients were obtained for 4 to 7 materials in each of 3 polystyrene-moderated critical assemblies. These results were analyzed on the basis of hydrogen-density of samples, by attempting to synthesize the reactivity coefficients, and by a simultaneous solution technique. Frequently polyethylene is used to simulate water. Reactivity coefficient measurements show the two are identical when compared on hydrogen density basis. Experiments have been performed over a wide range of core parameters to permit the evaluation of few group (2, 3, and 4) diffusion theory. Nineteen cores, 14 by 14 by 24 inches, reflected and moderated with polyethylene, have been measured. Five polyethylene-moderated assemblies with 36-inch lengths having cross sections from 17 by 21-inch rectangles to 32 inch diameter circles were studied. Few-group diffusion theory analysis gave good agreement with experiment. Survey studies have been made on plastic mockups of power reactors and for exploration of new reactor concepts. (auth)

15118 A/CONF.15/P/2391

Oak Ridge National Lab., Tenn.

AQUEOUS HOMOGENEOUS REACTOR FUEL TECHNOLOGY. 53p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Development of the technology of uranyl sulfate solutions and thoria slurries for power breeder reactors is outlined. In uranyl sulfate systems phase separations can occur in the temperature range of 250 to 300°C, although additions of sulfuric acid and alkali metal sulfates are effective in suppressing these. Dissolved copper is completely effective in recombining the hydrogen (or deuterium) and oxygen which are produced by the radiolytic decomposition of water in fissioning uranyl sulfate solutions. Alloys considered most as materials of construction for homogeneous reactors are Zircaloy-2, austenitic stainless steels, and commercially pure titanium. Austenitic stainless steels develop a protective anhydrous α Fe_2O_3 film at 250°C and higher temperatures. Stability of the film depends on solution composition, rate of flow and temperature. In the absence of an oxidant such as oxygen, uranyl ion is reduced and a very corrosive solution is formed. Crevices and stagnant regions where oxygen depletion can be encountered must be avoided. The out-of-pile corrosion behavior of stainless steel is relatively unchanged by exposure to a solution in which fission is taking place but where exposure is to solution circulating outside the neutron flux region. Zircaloy-2 is very resistant to attack in non-fissioning solutions. In-pile the corrosion rate increases with increasing power density and temperature. Titanium generally behaves like Zircaloy-2 but the in-pile corrosion rates are lower. Products accumulate in reactor solutions as a result of nuclear and corrosion processes and must be removed. The chemical behavior of some of the products has been investigated as have methods for their removal. Materials like iron, zirconium, barium, and the rare earths form insoluble salts or hydrolysis products which can be removed by filtration or centrifugation methods. Nickel, manganese, and cesium are soluble and are removed by solvent extraction or by separation of the uranium as a peroxide precipitate. Iodine, xenon, and krypton can be removed by stripping the fuel solution with oxygen or steam. Important progress has been made in developing thorium oxide slurry fuels for power

breeder reactors. Thoria has been produced with controlled particle size, shape and surface area. The effects of firing temperature in the range of 450 to 1600°C, and the effects of pH and additives such as sulfate and silicate on the thoria properties have been investigated. Slurries have been irradiated at power densities and for times equivalent to those expected in a thorium breeder blanket without important change in properties. Molybdenum oxide is a promising catalyst for recombining radiolytic gas. Heat transfer and fluid flow characteristics in both laminar and turbulent flow can be related to conventional correlations for Newtonian fluids through the non-Newtonian rheologic coefficients. Corrosion and erosion of structural materials are governed by the size and shape of the particles, the concentration and velocity and by the presence of additives. Data are being obtained to show the effects of radiation on corrosion. Thoria slurries have been circulated in engineering equipment for thousands of hours. Corrosion and erosion have been a problem only in the circulating pumps and in very high velocity or turbulence regions in the piping and valves. (auth)

15119 A/CONF.15/P/2402

General Electric Co. [Atomic Power Equipment Dept.,] San Jose, Calif. and Argonne National Lab., Lemont, Ill.

PHYSICS OF BOILING WATER REACTORS. [T. Snyder and J. Thie.] 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The reactor physics unique to boiling reactors results from the variable water density in the reactor core and the mutual interaction of the power and boiling water density distributions. At steady power these distributions must be compatible; during transients not only their time-dependence but that of the entire reactor system is involved. The success of the methods in describing operating experience with boiling reactors in the U. S., particularly the successful operation of the EBWR, is discussed. (W.D.M.)

15120 ACONF.15/P/2405

Babcock and Wilcox Co. Atomic Energy Div., Lynchburg, Va.

PHYSICS OF WATER MODERATED THORIUM REACTORS. M. C. Edlund, D. B. Wehmeyer, E. L. Secrest, and D. V. P. Williams. 25p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experimental reactor physics data for thorium water reactors are summarized. Reactivity lifetime considerations are presented including a comparison of the reactivity lifetime of U^{238} and Th reactors fueled with U^{235}. Critical experiments and results on several water moderated enriched U–Th assemblies are reported. Values of infinite medium multiplication constants and migration areas were derived using the supplementary measurement of the rate of change of reactivity with water height as a function of water height. The effective resonance integral of the metal and ThO_2 in the water lattices were derived from measurements of cadmium ratios of Th. The experimental results were compared with theory. (M.H.R.)

15121 A/CONF.15/P/2406

Brookhaven National Lab., Upton, New York.

MATERIAL AND FUEL TECHNOLOGY FOR AN LMFR. C. J. Klamut, D. G. Schweitzer, J. G. Y. Chow, R. A. Meyer, O. F. Kammerer, J. R. Weeks, and D. H. Gurinsky. 59p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The fuel constitution and materials technology of the U–Bi fueled reactor are reviewed. The solubility of U in Bi and the effects of corrosion inhibitors and fission products on solubility were investigated. Materials for corrosion resistance and mechanical strength at LMFR operating temperatures are studied. (W.D.M.)

15122 A/CONF.15/P/2407

Division of Licensing and Regulation, AEC. and Division of Inspection, AEC.

REACTOR SAFETY, HAZARDS EVALUATION AND INSPECTION. C. K. Beck, M. M. Mann, and P. A. Morris. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In the prevention of release and dispersal of radioactive fission products, the major factors are technical knowledge of reactor characteristics, inherent safety features or lack thereof in reactor design, and supervision and control of reactor operation. In recognition of the present incomplete state of technical knowledge and of the serious potential hazard from a reactor accident, there was evolved a certain conservative approach to the design of new reactors that also contributes to safety of operation. The procedures and criteria used by the U. S. Atomic Energy Commission in the location, hazards evaluation, and inspection of reactors in the U. S. are described. Some examples of inspection experience are given. (auth)

15123 A/CONF.15/P/2408

California. Univ., Livermore. Radiation Lab.

CRITICAL MEASUREMENTS AND CALCULATIONS FOR ENRICHED–URANIUM GRAPHITE–MODERATED SYSTEMS. H. L. Reynolds. 27p. (UCRL-5175). $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The experimental results on a variety of enriched-uranium, graphite-moderated systems, both with and without reflectors are presented. Also included are the results of the multi-group transport, and one- and two-dimensional diffusion calculations used to interpret the data. In general the University of California Radiation Laboratory systems were bare or one-dimensional in order to simplify the analysis. Efforts were made to obtain systems as close as possible to an idealized system containing only a homogeneous mixture of moderator and fuel with all extraneous factors removed. The Los Alamos Scientific Laboratory experiments were carried out with more complex geometries approaching more closely potential reactor systems. All of the assemblies utilized heterogeneous arrangements of moderator and thin uranium foils. The bare systems range in carbon-to-uranium atomic ratios from 300/1 to 2500/1. These systems are not truly thermal and are in a range where critical mass is extremely sensitive to size or buckling. Experiments were performed for these systems to determine accurately the effects of extraneous factors such as room return, control-rod void spaces, nonhomogeneity of fuel loading, moderator block porosities and poison content. The reflectors include graphite and beryllium in one-, two-, and three-dimensional arrangements. The constants used in the multigroup calculations are presented in tabular form. Eighteen energy groups were used. The same constants were used in the transport and diffusion calculations to allow comparison of the two methods of calculation. (auth)

15124 A/CONF.15/P/2420
Aerojet-General Nucleonics, San Ramon, Calif.
THE AGN 211 HOMOGENEOUS POLYETHYLENE-UO_2 POOL TYPE REACTOR. A. T. Biehl, R. P. Geckler, M. Harvey, and R. Henley. 23p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The AGN 211 reactor is a small pool-type reactor, designed as an inexpensive, low-power, inherently safe instrument for educational, medical, and experimental purposes. The fuel elements contain enriched (20% U^{235}) uranium dioxide particles homogeneously dispersed in radiation-stabilized polyethylene plastic moderator. The critical mass is approximately 780 g of U^{235}. Although the reactor was initially planned for one-watt operation, continuous operation up to 100 watts is possible, and the reactor may be intermittently operated up to powers of one kilowatt. (W.D.M.)

15125 A/CONF.15/P/2427
Atomic Power Development Associates, Inc. Detroit, Michigan.
AN APPRAISAL OF THE ENRICO FERMI REACTOR. A. Amorosi, and J. G. Yevick. 116p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A complete design analysis is presented and appraised in the light of current technology. Information obtained during reactor and plant development is reviewed. (D.E.B.)

15126 A/CONF.15/P/2428
Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.
SPERT I REACTOR SAFETY STUDIES. W. E. Nyer and S. G. Forbes. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The results of experimental studies of reactor kinetic behavior under runaway conditions are reported for the unpressurized Spert I reactor. Reactivity step transients and ramp transients are considered. Spert I core characteristics are given. (W.D.M.)

15127 A/CONF.15/P/2437
Argonne National Lab., Lemont, Ill.
DISASSEMBLY AND METALLURGICAL EVALUATION OF THE MELTED-DOWN EBR-I CORE. J. H. Kittel, M. Novick, R. F. Buchanan, and W. B. Doe. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

After removal of the blanket rods from the reactor in the conventional manner, the fuel section of the core was removed as a unit to a temporary hot cell on top of the reactor tank. Final disassembly of the last 153 elements was made at Argonne in an atmosphere of 99.5% nitrogen and 0.5% oxygen. Samples removed from the melted portion of the core were analyzed for alloy composition to determine the amount of mixing when the core was in the molten state. (W.D.M.)

15128 A/CONF.15/P/2447
Argonne National Lab., Lemont, Ill.
REPORT ON FULL SCALE POWER REACTOR PROJECTS IN THE UNITED STATES OF AMERICA. Norman Hilberry. 33p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A survey is presented of the full-scale power reactor projects under way in the United States in 1958. (C.H.)

15129 A/CONF.15/P/2462
Westinghouse Electric Corp. Bettis Plant, Pittsburgh and Division of Reactor Development, AEC.
SHIPPINGPORT ATOMIC POWER STATION (PWR). J. W. Simpson and H. G. Rickover. 19p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The design, construction, operation, and purpose of the Shippingport Reactor are briefly reviewed. Some of the more significant technological problems are discussed. (D.E.B.)

Nuclear Transformation

15130 A/CONF.15/P/652
California. Univ., Livermore. Radiation Lab. and California. Univ., Berkeley. Radiation Lab.
THE PROMPT RADIATIONS IN THE SPONTANEOUS FISSION OF Cf^{252}. Harry R. Bowman and Stanley G. Thompson. 10p. (UCRL-5038). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experiments are described and results given for measurements of fission fragment kinetic energy, neutrons emitted per fission, neutron multiplicity, gamma spectrum, neutron energies, and neutron and fission fragment velocities. (W.D.M.)

15131 A/CONF.15/P/660
Los Alamos Scientific Lab., N. Mex.
THE DYNAMICS OF NUCLEAR FISSION. D. L. Hill. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The properties of nuclear matter in massive motion are examined in three successive approximations to completeness of representation: the liquid drop model, the collective model, and the collective model with residual inter-particle forces. (W.D.M.)

15132 A/CONF.15/P/665
Los Alamos Scientific Lab., N. Mex.
NEUTRONS AND RADIATIONS FROM FISSION. R. B. Leachman. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Qualitative data on the neutrons and gamma rays from fission fragment de-excitation and decay have been of great practical use. Recent work is sufficiently detailed and accurate to be quantitatively related to recent theoretical analyses of the identity and yields of delayed neutron precursors, the energy and number of prompt neutrons, and the energy of prompt gamma rays. In addition, new observations on electromagnetic radiation from fission are reported. (auth)

15133 A/CONF.15/P/670
Oak Ridge National Lab., Tenn.
GAMMA RAYS ASSOCIATED WITH FISSION. F. C. Maienschein, R. W. Peelle, W. Zobel, and T. A. Love. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Measurements of the energy spectra and time distribution of the fission-associated gamma rays are described. New data for thermal neutron-induced fission in U^{235} is presented covering the energy range between 0.3 and 8.0 Mev. Gamma-ray energy analysis was carried out with a multiple-crystal scintillation spectrometer employing either Compton scattering of pair production to give "unique" pulse-height response.

The importance of unique spectrometer response is explained. The gamma-ray spectrometer was operated in coincidence with a spiral-wound fission chamber by the use of a four-fold coincidence circuit having a resolving time of 6×10^{-8} sec. Spectral measurements for delayed fission radiation were obtained with a similar gamma-ray spectrometer. Energy distributions from 0.3 to 5.4 Mev are presented for ten delay times between 1.7 and 1550 sec. Gamma radiation delayed between 6×10^{-8} and 3×10^{-6} sec after fission was observed following thermal-neutron induced fission. This radiation appeared to be about 6% as intense as the prompt radiation. No gamma-rays in the range from 3 to 7×10^{-6} sec were observed within limitations imposed by random backgrounds. No measurements were reported in the time range between 7×10^{-6} sec and 1 sec. New data presented include time time dependence of the gamma radiation delayed from 1 to 1600 sec after fission, divided into six gamma-ray energy intervals between 0.28 and 5.0 Mev. These data are in good agreement with the energy-spectral data. Comparisons are also made with data available from gross fission-product photoneutron yields and chemically separated fission-product nuclides. (auth)

15134 A/CONF.15/P/677
Washington. Univ., Seattle.
FISSION STUDIES OF ELEMENTS LIGHTER THAN THORIUM. A. W. Fairhall, R. C. Jensen, and E. F. Neuzil. 23p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The fission cross sections of Au^{197}, Pb^{204}, Pb^{206}, Pb^{207}, and Pb^{208} for alpha particles were measured as a function of the formation of Y^{93}. The yield-mass distributions of Bi^{209} fissioned by 22-Mev deuterons and Ra^{226} fissioned by 23.5- and 43-Mev alpha particles, 11-Mev protons, and 22-Mev deuterons have been obtained. (W.D.M.)

15135 A/CONF.15/P/678
General Atomic Div., General Dynamics Corp., San Diego, Calif.
YIELD-MASS DISTRIBUTIONS IN THE PHOTOFISSION OF RADIUM AND OTHER HEAVY ELEMENTS. R. B. Duffield, R. A. Schmitt, and R. A. Sharp. 40p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Fission products from Ra^{226} in the mass range 70 to 150 have been isolated. Masses of 113 and 140 have approximately equal yields at 23-Mev x-ray energy. There are not sufficient yield data at present to establish whether the photofission yield-mass distribution from Ra^{226} has the three peak shape which has been reported from photofission. The branching ratio for photofission to photoneutron emission for Ra^{226} was 0.003. (W.D.M.)

15136 A/CONF.15/P/688
Argonne National Lab., Lemont, Ill.
NUCLEAR FISSION PROCESS: A STUDY OF THE COMPETITION BETWEEN FISSION AND NEUTRON EMISSION AS A FUNCTION OF EXCITATION ENERGY AND NUCLEAR TYPE. Robert Vandenboach and J. R. Huizenga. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

An attempt is made to bring together and correlate all the available information on the probability of heavy elements (with atomic number greater than or equal to 88) to undergo fission when excited to 8 Mev or greater. Due to the nature of the experimental data available, it is necessary to treat the competition between fission and neutron emission rather than simply the probability for fission. The competition between neutron emission and fission is given quantitatively by the ratio of the neutron emission width Γn to the fission width Γ_F. Values of this ratio are deduced from all available photo photofission cross sections, fast neutron and charged-particle induced fission cross sections, and spallation cross sections. Discussion of neutron widths and fission widths derived from resonance energy neutron cross sections are omitted. Correlations of the resulting values of $\Gamma n/\Gamma_F$ with the liquid drop model fissionability parameter Z^2/A and other possible parameters are investigated. It is of particular interest but also experimentally more difficult to determine the excitation energy dependence of the quantity $\Gamma n/\Gamma_F$. An attempt is made to draw some qualitative conclusions on this subject from analysis of fast neutron fission, photofission, and high energy charged particle excitation functions. (auth)

15137 A/CONF.15/P/690
Argonne National Lab., Lemont, Ill.
AN EXPERIMENTAL STUDY OF FISSION IN THE ACTINIDE ELEMENTS. A. Smith, P. Fields, A. Friedman, S. Cox, and R. Sjoblom. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The results of a recent experimental investigation of the fission properties of some actinide elements are presented. The study includes: fission fragment kinetics, fission neutron spectra, prompt gamma rays from fission, and delayed neutrons from fission. The kinematic distribution of the fission fragment modes of Th^{229}, Pu^{240}, P^{241}, Cm^{242}, Cm^{244}, Cf^{252}, and Fm^{254} were determined using a high resolution back-to-back ionization chamber. The fission neutron spectra of U^{233}, Pu^{241}, and Cf^{252} were measured from 0.2 to 10.0 Mev. The prompt fission gamma spectrum of Cf^{252} was measured from 0.075 to 10.0 Mev using single and double crystal scintillation spectrometers. The periods and yields of the delayed neutron groups emitted in the fission of Cf^{252} were measured. The integrated yield per fission was found to be $\sim 1/100$ that of U^{235}. (W.D.M.)

15138 A/CONF.15/P/691
Argonne National Lab., Lemont, Ill.
HALOGEN DELAYED-NEUTRON ACTIVITIES. Andrew F. Stehney and Gilbert J. Perlow. 15p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Fission-product bromine was separated rapidly from fission-product iodine and the neutron activity of either species was counted. This was done by irradiating with thermal neutrons a solution of U^{235} containing the reagents for transforming the unwanted halogen into nonvolatile form. Air containing some of the desired halogen as carrier is swept rapidly through the solution and carries the halogen of interest to a tube which holds a number of glass beads wet with carbon tetrachloride. The halogen dissolves in the surface film while the air and rare gases are carried on out. The neutrons emitted from the tube are counted by a neutron counter after moderation in paraffin. The irradiation time is varied from a fraction of a second to several minutes. The sweeping process is generally started about 0.2 seconds after the end of irradiation and lasts for ~1.2 seconds, during which time about 0.5 liter of gas was transported through 4 ml of solution. All operations

are carried out automatically by use of a timer and electrically operated valves. The neutron counts are scaled and recorded on tape with a pen recorder. The initial counting rates are normally in excess of 1000 per second and for some irradiations are as high as 15,000 per second. The decay of the neutron activities is followed to background, which is typically about 1.5 per second. The decay curves are analyzed into periods by conventional graphical techniques. For bromine, neutron activities are found having the following half lives: 54, 15.5, 4, and 1.5 seconds. The assignment of mass numbers is most likely to be 54-second Br^{87}, 15.5-second Br^{88}, 4.0-second Br^{89} and 1.5-second Br^{90}. For iodine, half-lives of 24.4, 6, and 2.5 seconds were found. The mass assignment appears to be 24.4-second I^{137}, 6-second I^{138} and 2.5-second I^{139}. Decay data from unseparated samples are customarily analyzed into six components of which two are appreciably shorter in half-life than those found. Since seven are already separated, it appears that at least nine periods exist. None of the new activities reported may be considered to have relatively small yield, all being more abundant than the 54-second Br^{87}. It is apparent that measurements of half-lives, yields, and neutron energies which were done with unseparated samples should be reexamined in the light of the new periods. (auth)

15139 A/CONF.15/P/725
Oak Ridge National Lab., Tenn.
ALPHA-PARTICLE EMISSION FROM ORIENTED Np^{237} AND U^{233} NUCLEI. L. D. Roberts, J. W. T. Dabbs, and G. W. Parker. 26p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The nuclei U^{233}, U^{235}, and Np^{237} were aligned by quadrupole hyperfine structure coupling at liquid helium temperatures. The angular distributions of the alpha particles emitted in the decay of these nuclei and the angular distribution of the fragments from the thermal fission of U^{233} were observed as a function of nuclear alignment. (W.D.M.)

15140 A/CONF.15/P/1429
California. Univ., Berkeley. Radiation Lab.
SPALLATION FISSION COMPETITION IN THE HEAVIEST ELEMENTS. T. Darrah Thomas, Bernard G. Harvey, and Glenn T. Seaborg. 15p. (UCRL-3989). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Reactions induced in fissionable elements by deuterons and helium ions were studied. Results from excitation-function measurements, the dependence of $(\overline{\Gamma_n/\Gamma_f})$ on Z and A, and tritium production by charged-particle bombardment of Au, Th, and U are plotted. It was found that although most of the reactions involve formation of a compound nucleus, the reactions that survive fission best are those going by a direct interaction without the formation of a highly excited compound nucleus. (M.H.R.)

15141 A/CONF.15/P/2440
California. Univ., Berkeley. Radiation Lab.
HEAVY ION REACTIONS WITH HEAVY ELEMENTS. Albert Ghiorso and Torbjørn Sikkeland. 17p. (UCRL-8292). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Results obtained with Berkeley Heavy Ion Linear Accelerator concerning the interactions of heavy ions with the heavy nuclides are presented. The production of isotopes with Z at least as high as the target nucleus is discussed. The following topics are covered: the experimental methods, neutron evaporation reactions, reactions involving charged particle emission, the discovery of element 102, and the search for elements with atomic number greater than 102. (M.H.R.)

Particle Accelerators

15142 A/CONF.15/P/346
Naval Research Lab., Washington, D. C.
STEADILY RUNNING SELF-FOCUSING STREAMS. W. H. Bennett. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A method is proposed for producing a steadily running self-focusing stream of relativistic electrons and space charge neutralizing ions in a closed loop. Electrons from a linear accelerator are injected at full energy into a magnetic guide field similar in form to that of a cyclotron. The electrons injected in each pulse are held in the field during the injection pulse with the assistance of Tuck and Teng peeler and regenerator field bumps in reverse order, although the action is not strictly the reverse of the Tuck and Teng system. Following each injection pulse, the radius of the injected loop is shrunk by an increase in guide field long enough for the electrons to radiate energy and shrink in loop radius too much to escape. By successive injections of electrons, the cycling current is built up to the minimum critical value for self-focusing and held there. (auth)

15143 A/CONF.15/P/726
Ames Lab., Ames, Iowa.
ELECTRON BEAM CONTROL IN A CONVENTIONAL SYNCHROTRON. C. L. Hammer and L. Jackson Laslett. 13p. (ISC-1016). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Precise control of the rate at which the electron beam of a conventional weak-focusing synchrotron strikes a target internal to the synchrotron vacuum chamber is sometimes essential to the performance of a physical measurement. For example, the excitation and measurement of short half lives or neutron time of flight measurements demand a beam burst that is as short as possible, sometimes of the order of millimicroseconds. At the other extreme, coincidence measurements between nuclear fragments from the photodissociation of nuclei demand an extended beam burst of the order of milliseconds. In addition to these considerations, it is also desirable to be able to extract the electron beam from the synchrotron with as high a yield as possible. Toward these ends perturbation techniques have been developed and tested using the Iowa State College 75-Mev synchrotron as a model. To obtain short beam bursts two methods have been employed, one using a half-integral resonance and the other using an integral resonance. The first method has the advantage of causing the electron beam to expand onto a target in approximately ten revolutions. Furthermore, this expansion is azimuthally dependent making the method also useful for beam extraction. The second method, while causing beam destruction more slowly than the first (about 5 microseconds), is more applicable to activation experiments where precise control of the direction of the resulting Bremsstrahlung is desirable. Both methods utilize a magnetic deflection scheme. The usual method for obtaining protracted beam pulses by amplitude modulation of the synchrotron r-f system is not applicable to the

lower energy machines since radiation losses are low. It is found, however, that frequency modulation of the r-f system at the peak of the magnetic guide field gives beam pulses of the order of two milliseconds duration. This is to be compared to a total acceleration time of six milliseconds. (auth)

15144 A/CONF.15/P/736
Naval Research Lab., Washington, D. C.
STATUS OF THE NRL ELECTRON GUIDE FIELD PROJECT. D. C. dePackh. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A guide field of the Budker type is considered, in which an electron beam of about 1 ka is injected into hydrogen in a strong focusing external magnetic field at densities from 0 to 10^{15} atoms per cc. Final beam radii should range from 10^{-2} to 10^{-3} cm. The quasi-stationary contraction of the beam as well as some aspects of the stability question will be taken up. Current experiments and proposed ones will be discussed. (auth)

15145 A/CONF.15/P/793
Office of the Quartermaster General, Washington, D. C.
THE UNITED STATES ARMY IONIZING RADIATION CENTER. R. Pomerantz and J. L. Mastran. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

One of the principal milestones in the Radiation Preservation of Foods Program is the establishment of the U. S. Army Ionizing Radiation Center at Stockton, Calif. The center is designed to demonstrate the technological and commercial feasibility of the radiation preservation of foods, to stimulate the interest of the food processing industry in this process, and to produce the quantities of foods required for projected studies. The center will include a processing building for the preparation of raw materials, radiation sources, and irradiation chambers. The maximum rated capacity of the plant will be 1½ tons of food products per hour based on a treatment of 1.86×10^6 rad (2×10^6 rep). The facility is designed for automatic and continuous passage of commodities through the irradiation chambers, and is scheduled for completion by July 1960. (J.R.D.)

15146 A/CONF.15/P/1771
Applied Radiation Corp., Walnut Creek, Calif.
ISOTOPE PRODUCTION WITH AN ELECTRON LINEAR ACCELERATOR. Malcolm H. MacGregor. 11p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Calculations were made of the isotope production rates by gamma radiation from an electron accelerator. Of 84 radioisotopes considered, 58 cannot be made in a reactor by the (n,γ) process, and only 14 are listed in the current Oak Ridge catalog. Of the 26 radioisotopes that can be reactor-produced, 17 have half-lives shorter than three days, so that on-the-spot production with an accelerator would be an advantage. The specific activities produced are typically millicuries per gram, and production rates compare favorably with cyclotron isotope production rates. The isotope production calculations were based on experimentally measured cross sections, using 10 kw electron linacs operated at 20 Mev and 25 Mev as typical radiation sources. Electron linacs of this size produce gamma rays equivalent in total energy to Co^{60} sources in the megacurie range. High energy electron linacs can also be operated as fairly intense neutron sources. Linacs such as mentioned above, when used with uranium targets, have total neutron production rates of about 3×10^{13} neutrons per second and can produce peak thermal fluxes equivalent to a homogeneous reactor operated at 5 kw. (auth)

15147 A/CONF.15/P/2400
Wisconsin. Univ., Madison. and Midwestern Universities Research Assn., Madison, Wis.
ACCELERATOR DEVELOPMENTS IN THE UNITED STATES. Keith R. Symon. 9p. $0.59(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Characteristics of the Cosmotron, Bevatron, the proton synchrotron at UCRL, electron synchrotrons at Cornell and CIT, and the electron linear accelerator at Stanford are described briefly. Descriptions are given of four multi-Bev accelerators now under construction or in final stages of design. A design study has been carried out at Stanford Univ., on a 40-Bev electron linear accelerator. Preliminary design studies of a multi-Bev fixed-field alternating-gradient accelerator are described. (W.D.M.)

15148 A/CONF.15/P/2432
Stevens Inst. of Tech., Hoboken, N. J. and Brookhaven National Lab., Upton, N. Y.
THE MEGATRON. D. Finkelstein. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

This apparatus is intended to produce a plasma of 1000 amperes of 100 Mev electrons and an equal number of neutralizing ions. Some novel features of the design are: the use of a single one-turn coil to provide the entire accelerating and guide fields of the apparatus; guiding magnetic fields and accelerating electric fields larger than those used in accelerators at present; and plasma injection to get the necessary number of particles into the place where they will be accelerated. The physical principles of the Megatron are presented and energy storage, injection, and the field coil are discussed. (M.H.R.)

Radiation Absorption and Scattering

15149 A/CONF.15/P/649
California. Univ., Livermore. Radiation Lab.
EXACT PHASE-SHIFT CALCULATION FOR NUCLEON-NUCLEAR SCATTERING. Frank Bjorklund and Sydney Fernbach. 13p. (UCRL-5028). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Nuclear scattering data presently available make it feasible to study the energy dependence of optical-model parameters from fairly low energies to several hundred Mev. This is particularly true for proton scattering from heavy nuclei, where some nonelastic cross sections as well as differential cross sections and polarization data are available at energies between approximately 5 and 400 Mev. For neutron scattering, there are very few reliable data above 50 Mev, but the region between 1 and 50 Mev can be studied primarily because nonelastic and total cross sections have been measured. The best elastic neutron scattering data exist up to and including 14 Mev. Further calculations are being performed at 1 Mev and at energies above 14 Mev in order to determine the variation in the potential parameters. Comparisons are made at each energy between the results for the above central imaginary potential and the more usual form in which the imaginary potential has the same form factor as given for

the real potential above. The proton-scattering calculations show that the same potentials as used in the neutron calculation adequately describe the nucleus. Since more precise data and a greater range of energy are available, more effort is being put into the proton calculation. Preliminary results have been obtained at energies of 17, 40, 95, 135, and 300 Mev. At the higher energies, the imaginary spin-orbit term becomes essential. The central imaginary potential varies slightly with energy, the central real potential falls off as expected and may become negative (repulsive) above 300 Mev. (auth)

15150 A/CONF.15/P/668
Los Alamos Scientific Lab., N. Mex.
ELASTIC SCATTERING OF COMPLETELY POLARIZED 10-MEV PROTONS BY COMPLEX NUCLEI. L. Rosen and J. E. Brolley, Jr. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The motivation for the present experiments was to devise a method for directly observing the effects of the spin-orbit force in the intermediate energy region, where it is believed to play a prominent part in nucleon-nuclei interactions, as well as in nuclear structure. The method involves the production of an intense beam of 100% polarized protons which is then used to study the differential cross section for elastic scattering from various nuclei. The polarized proton beam is generated by scattering 28-Mev He^4 ions from hydrogen. The protons emitted at 130° in the c-m system are completely polarized and, under the conditions of the experiment, have an intensity of 10^{10}/steradian sec with the spin axes all directed along the X axis when the incoming alpha particle beam velocity vector is along the Z axis in a right-handed coordinate system. The degree of polarization of the beam was established by performing a second scattering in helium through the same scattering angle and measuring the azimuthal asymmetry of the scattering cross section. (auth)

15151 A/CONF.15/P/2426
Argonne National Lab., Lemont, Ill.
DISTRIBUTION OF ANGULAR MOMENTA OF RESONANCE LEVELS FOR NEUTRON SCATTERING. Carl T. Hibdon. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Virtual nuclear energy levels can be located and studied by the variation of the neutron total cross section as a function of neutron energy. Measurements on Al^{27} from about 1 to 450 kev are described. The level spacings, resonance parameters, strength functions, the distribution in sizes of the resonance widths, and the distribution of the angular momenta among the levels of the compound nucleus are studied. The measurements revealed a small number of s-wave scattering resonances and a profusion of resonances of the p- and d-wave variety. These are all levels of the single nuclide Al^{28}. (W.D.M.)

Radiation Effects

Refer also to abstracts 14636, 14765, and 15178.

15152 A/CONF.15/P/462
Brookhaven National Lab., Upton, N. Y.
CONTROL OF RADIATION EFFECTS IN A GRAPHITE REACTOR STRUCTURE. R. W. Powell, R. A. Meyers, and R. G. Bourdeau. 32p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A procedure was devised for releasing stored energy under controlled operating conditions. This was accomplished in the Brookhaven Reactor's first annealing operation and was accompanied by a fractional reduction of the dimensional growth which had occurred up to that time. Annealing operations are being conducted at more frequent intervals. As the data of these more frequent annealing operations are studied, perhaps a new and more interesting effect is being observed, namely that the growth is approaching an equilibrium maximum value, which probably depends on the annealing procedures. This view is confirmed by 4 in. long graphite samples that have been irradiated in the pile and measured within ±0.00003 in. for growth changes after different annealing treatments. These samples show that the percent contraction or recovery of the graphite on annealing is proportional to its growth since the last anneal. This gross growth value is dependent on the short time temperature history of the reactor and not the average temperature. The rate of C-axis increase is approximately ten times the rate of gross growth after a thermal or pile anneal. The changes in dimensions and C-axis as well as the compressive strength and stored energy are discussed. Correlations between some of these properties are presented. It is concluded that sufficient information is now available on the rates of graphite growth under varying conditions and on methods of controlling growth, that graphite structures might be designed with considerably more assurance than in the past. (auth)

15153 A/CONF.15/P/612
Brookhaven National Lab., Upton, N. Y.
RADIATION ENHANCED DIFFUSION IN SOLIDS. G. J. Dienes and A. C. Damask. 22p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Recent theoretical and experimental work on radiation enhanced diffusion is discussed. A simple theory has been worked out which describes the dependence of this enhancement on flux and temperature under steady state conditions. The theoretical study also shows that the measurement of enhanced diffusion as a function of temperature can indicate the mechanism by which defects are removed from the lattice. Alpha brass was chosen for experimental work because it is a kinetically simple system, not complicated by nucleation, in which diffusion is easily followed by measuring the change in short-range order. Experiments on alpha brass verified several aspects of the simple theory. An enhancement in diffusion rate by about a factor of 10^7 was observed at 50°C during irradiation at a flux of 5×10^{12} neutrons cm^{-2} sec^{-1}. This enhancement is essentially independent of temperature in the 0 to 50°C range, in agreement with theoretical predictions for the case where the radiation induced defects finally disappear at internal surfaces. 2 Mev electrons were shown to be considerably less efficient, by about a factor of 14, because vacancy-interstitial pairs are produced close to each other and recombine easily. The practical implications of radiation enhanced diffusion, and hence increased reaction rates in solids, are also outlined. A separate study of the tin transformation shows that particle irradiation can nucleate this transformation at low temperature. The combination of the two kinetic problems as studied on the simple systems of alpha brass and grey tin enable one to examine the effect of radiation on complex metallurgical processes from a more sophisticated standpoint. The separate studies of diffu-

sion enhanced by neutron-, electron-, and γ-irradiation allow one to estimate the combination of their effects under a variety of radiation conditions. The problem is further complicated, however, by the existence of thermal spikes which can contribute to enhancement of diffusion but can also disrupt clusters of precipitated or ordered atoms. The relative importance of these various competing processes in several binary metallurgical systems is discussed. (auth)

15154 A/CONF.15/P/616
Knolls Atomic Power Lab., Schenectady, N. Y.
SOURCES OF FUEL ELEMENT INSTABILITY. A. H. Willis. 12p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Analysis of fuel element instability from various USA-AEC sources indicates that fission products have a marked effect on the mechanical behavior of fuel materials, and that the instability of fuel materials may be decidedly dependent upon the conditions of reactor operation, for example, the fuel element power density. The phenomena which establish the volume stability of fuel elements is discussed both from the viewpoint of the mechanical response of fuel materials and the sources of instability in fuel materials. Experimental data substantiating these conclusions are presented. (auth)

15155 A/CONF.15/P/619
Westinghouse Electric Corp. Bettis Plant, Pittsburgh.
IRRADIATION INDUCED PHASE CHANGES IN URANIUM-BASE ALLOYS. M. L. Bleiberg. 21p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Examination of pile-irradiated uranium–molybdenum alloys has shown that the room-temperature stable phase transforms to the metastable high-temperature phase due to neutron bombardment. This was determined by measurements of electrical resistivity, temperature coefficient of electrical resistivity, hardness, density, and x-ray-diffraction patterns. In addition, evidence is shown for an order-disorder reaction in uranium–molybdenum alloys. A special low-temperature facility, designed to obtain the kinetics of these reactions, is described. The results of the low-temperature kinetic studies of these reactions is presented. The mechanism of the phase reversal is explained on the basis of the results of these tests. (auth)

15156 A/CONF.15/P/621
Argonne National Lab., Lemont, Ill.
THE EFFECT OF REACTOR IRRADIATION ON THE PHYSICAL PROPERTIES OF BERYLLIUM OXIDE. J. R. Gilbreath and O. C. Simpson. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experimental data obtained at Argonne on the effects of pile irradiation on the physical properties of beryllium oxide and beryllium oxide–uranium oxide compacts are summarized. The physical properties discussed include bulk dimensions, lattice dimensions, compressive strength, elastic modulus, specific heat, thermal conductivity, and magnetic susceptibility. Samples of pure beryllia, of 2% UO_2–98% BeO, and of 10% UO_2–90% BeO were studied. To enhance the fission fragment damage, uranium of 30% U^{235} content was used. Irradiations of 54, 109, and 219 Mwd/at were performed. In these irradiations one Mwd/at (Megawatt day per adjacent ton) was equivalent to about 1.8×10^{17} fast neutrons/cm^2 and 6×10^{17} slow neutrons/cm^2. All properties of pure beryllia except the thermal conductivity are affected only slightly by exposure to reactor irradiation corresponding to an integrated fast neutron flux of about 3.6×10^{19} neutrons/cm^2. The thermal conductivity decreased approximately 40% during this irradiation. Considerably greater changes were observed in the BeO–UO_2 samples exposed to fast fission fragments. A portion of these irradiation-induced changes may be annealed out by heating at 900°C. Details of the results are discussed. (auth)

15157 A/CONF.15/P/802
General Atomic Div., General Dynamics Corp., San Diego, Calif.
ELECTRICAL EFFECTS OF HIGH-INTENSITY IONIZING RADIATION ON NONMETALS. Victor A. J. van Lint and P. H. Miller, Jr. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Experiments were performed utilizing a 7-Mev electron linear accelerator. Ionization rates up to 5×10^8 r per sec during 10-μ pulses were achieved. In this environment typical resistors became shunted by 3×10^4 to 10^5 ohms, capacitors leaked their stored charge in 10 to 100 μ, and semiconductor junctions became shorted in the back direction for up to ten minority-carrier lifetimes unless the excess carriers were swept across the junctions by large currents. Theories are developed to explain the effects in resistors and semiconducting devices. Further detailed experiments are being performed. (auth)

15158 A/CONF.15/P/821
North Carolina State Coll., Raleigh. School of Textiles.
THE EFFECT OF NUCLEAR RADIATION ON FIBROUS MATERIALS. Otto Teszler and Henry A. Rutherford. 9p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

In a comprehensive series of experiments, fibrous materials were exposed to thermal neutrons and to gamma rays at various dose rates and at different total dose levels. The effects on all significant physical and chemical properties of the fibrous materials were evaluated. Widely different orders of stability were found among polymers, but there was no essential difference in behavior of the individual polymers, at equal dosages, when exposed to the different kinds of radiation, nor was there any effect of dose rate. The ultimate change in the polymer was a function of total dose of radiation only and varied with the polymer treated. The degree of orientation had a noticeable influence on the tendency of the polymer to be either predominantly cross-linked or predominantly degraded, degradation being defined in this case as scission of long-chain molecules. It was possible to rate those polymers that are principally degraded in an order of stability based on the number of chemical linkages broken at any given dose of radiation. Experiments were conducted currently to determine the possibility of modifying cellulosic materials with a minimum of degradation by exposure to radiation in the presence of cross-linking agents such as aldehydes. (auth)

15159 A/CONF.15/P/1069
Brookhaven National Lab., Upton, N. Y.
DEVELOPMENT OF HIGH POWER IRRADIATORS. B. Manowitz, O. Kuhl, D. Richman, and L. Galanter. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Two systems are considered—one a nuclear reactor through which an aqueous solution of an indium salt is circulated and subsequently also circulated through the irradiator; the other, a device made up of plates of Co^{60}. Experimental data are presented on corrosion behavior of indium solutions against various materials of construction, stability of indium solutions, and dose distribution of radiations from indium solutions in an absorbing medium. The dose distribution study was made on large-scale, low-level irradiators. Experimental results are compared with theoretical. From the experimental data on dose received at a known curie input, the power required for the nuclear reactor in order to achieve full-scale throughput is estimated. Design parameters for the cobalt-60 irradiator are analytically determined. Some experimental data are compared with the theory. (auth)

15160 A/CONF.15/P/1890

Argonne National Lab., Lemont, Ill.

EFFECT OF IRRADIATION ON FUEL MATERIALS. J. H. Kittel and S. H. Paine. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Research on satisfactory solid fuel materials for power reactors has included extensive irradiation investigations of fuels based on metals, cermets, and ceramics. The ability of each type of fuel to resist irradiation damage during extended reactor exposure is dependent upon many interrelated factors. These factors for each of the three types of fuel in the light of available experimental information is discussed. Irradiation effects on metallic fuels based on uranium, plutonium, and thorium are discussed, particularly in regard to results obtained from high burnup experiments at elevated temperatures. The influence of such alloying additions as chromium, molybdenum, niobium, silicon, and zirconium is described. Also included is a discussion of recent experimental results on fast reactor fuels containing uranium, plutonium, and the "fissium" elements. Since the influence of irradiation temperature is especially large when dealing with metallic fuels, recent experimental data on the effects of irradiation temperature are discussed. (auth)

15161 A/CONF.15/P/1978

Oak Ridge National Lab., Tenn.

EFFECTS OF IRRADIATION ON THE STRUCTURAL MATERIALS IN NUCLEAR POWER REACTORS. J. C. Wilson. 26p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The mechanical properties of more than fifty metals, alloys, and welds useful in power reactor technology were determined after irradiation doses from 10^{18} to 10^{20} fast neutrons/cm^2 at various irradiation temperatures. The influence of composition, heat treatment, and microstructure on the sensitivity to radiation effects and the effect of test variables such as strain rate and specimen type were studied for a number of materials. Although structural metals are among the least sensitive of materials to adverse effects of irradiation, there are areas in which radiation effects can strongly influence design, construction, and operation of reactor components. (auth)

15162 A/CONF.15/P/2384

California Research Corp., Richmond, Calif. and General Electric Co., Richland, Wash.

ORGANIC LUBRICANTS AND POLYMERS FOR NUCLEAR POWER PLANTS. Robert O. Bolt, James G. Carroll, Robert Harrington, and Richard C. Giberson. 32p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Conventional lubricants are limited in usefulness in the presence of radiation because many contain radiation sensitive ingredients. The most resistant materials do not resemble known lubricants. Alkyl aromatic fluids, themselves not heretofore used in oils and greases, were found to be a good compromise as new base materials for such products. Alkyl diphenyl ethers had the best combination of physical properties and lubricity. Other more available alkyl aromatic materials had inadequate viscosity and viscosity-temperature characteristics. Such deficiencies were partly corrected by the addition of fluid polymers with a minimum effect on radiation resistance. These polymers were also very effective in the ether derivatives. Radiation greatly accelerates the oxidation of all organic fluids. Certain compounds containing selenium or sulfur were found to be the most satisfactory in reducing this effect. Radiation resistant oils from alkyl diphenyl ethers or alkyl aromatic-polymer mixtures, each containing these inhibitors, were gelled with conventional aliphatic soaps to make new greases. Improved radiation resistance was obtained; even better greases ensued when aromatic gelling agents were used. These finished oils and greases performed well after radiation doses which destroyed conventional products. As with organic fluids, the radiation resistance of elastomers and plastics depends upon the base material and upon the additives or compounding ingredients used. An extensive survey of the common solid polymers showed polyurethanes to be the most resistant of the elastomers while poly(vinyl chlorides) were the best of the flexible plastics. The use of different compounding recipes was found to affect the radiation resistance of these materials by as much as tenfold. Radiation induced cracking in elastomers which were stressed and occurred only in materials which were not ozone resistant. Chemical changes occurring in the radiolysis of thin films of solid polymers were studied with the infrared spectrometer. (auth)

15163 A/CONF.15/P/2385

Oak Ridge National Lab., Tenn.; General Electric Co. Research Lab., Schenectady, N. Y.; and Illinois. Univ., Urbana.

ON THE INTERPRETATION OF RADIATION EFFECTS IN THE NOBLE METALS. D. K. Holmes, J. W. Corbett, R. M. Walker, J. S. Koehler, and Frederick Seitz. 20p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The existing investigations of noble metals bombarded near liquid helium temperatures suggest very strongly that a large fraction of the change in resistivity is associated with the production of interstitial atoms and vacancies. The interstitial atoms migrate in the range above about 15°K with activation energies near 0.1 ev and, to a considerable extent, annihilate vacancies. The migration occurring at the lowest temperatures probably involves close interstitial-vacancy pairs which coalesce. More isolated interstitial atoms migrate at somewhat higher temperatures and form clusters as well as annihilate vacancies. The migration is influenced significantly by foreign atoms. The annealing kinetics merit further investigation. The observations on mechanical properties are consistent with the migration of isolated interstitial atoms in the 30 to 50°K temperature range, but indicate that, at least for the case of

irradiation with fast neutrons, there may be more complicated effects than those which seem to explain the major features of the resistivity and dimensional changes. (auth)

Radioactivity

15164 A/CONF.15/P/404

California. Univ., Berkeley. Kearney Foundation of Soil Science.

WEATHERING OF GREAT WORLD SOIL GROUPS AS RELATED TO GENERAL ATMOSPHERIC RADIOACTIVITY. C. C. Delwiche. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

All soils are constantly generating isotopes of radon. By diffusion and pumping action of wind gusts these isotopes enter the atmosphere. Over the oceans these radioactive gases and their decay daughters reach their lowest intensity whereas over land they attain their maximum. Highest atmospheric radiation intensities are reached under conditions of still air, particularly where inversion layers prevent vertical mixing of the overlying atmospheric mass. Of the average composition of 10^{-12} grams radium per gram for the earth's crust, individual rocks vary greatly in their radium contents with granites generally in the order of 5×10^{-12} grams/gram and calcareous deposits 1/20th of this amount. However as a result of weathering, the large amounts of calcareous parent rock contributing to the eventual soil mass concentrates radium in the soil. Granite rocks may yield soils lower in radium content than the parent rock from which they are derived. Thus weathering of rock into soils tends toward similar radium contents for soils regardless of parent rock. These points are illustrated by measurements of the radon gas generating powers which have been made on profiles of ten different great world soil groups. Soil samples were taken from Australia, Brazil, and the United States of America. (auth)

15165 A/CONF.15/P/742

Roswell Park Memorial Inst. Dept. of Radiation Therapy, Buffalo.

ELECTRON STOPPING POWERS RELATIVE TO AIR. Norman A. Baily and George C. Brown. 14p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The stopping powers for electrons from S^{35}, P^{32}, and Y^{90} were determined for H, He, N, O, Ne, Ar, Kr, and Xe relative to air. The stopping powers are presented both on a per gram and a per electron basis. The experimental results indicate that there are at least two different groups of values for the average ionization potential. (W.D.M.)

15166 A/CONF.15/P/750

National Bureau of Standards, Washington, D. C.

RADIOACTIVITY STANDARDIZATION IN THE UNITED STATES. Wilfrid B. Mann and H. H. Seliger. 8p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The preparation of primary standards of radioactivity is discussed together with the techniques in use for the maintenance of primary and secondary standards and the methods available for the routine and accurate comparison of primary and secondary standards. The methods and techniques include counting, ionization, and microcalorimetric measurements. Particular emphasis is laid on the results obtained using precision compensated internal gas counters that have recently been developed at the National Bureau of Standards. The standardization of Kr^{85} and Po^{210} is described. (auth)

15167 A/CONF.15/P/755

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

SURFACE DOSE FROM PLUTONIUM. W. C. Roesch. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A theoretical study was made of the dose rate to be expected at the surface of a material of high atomic number that is emitting gamma rays. Fluoresence radiation was taken into account. Scattering within the emitter was neglected but backscattering from tissue in contact with the emitter was allowed for semi-empirically. The results are useful in predicting dose rates from radioactive products or contaminants in plutonium, uranium, etc. The dose rate at the surface of reactor produced plutonium was calculated as a function of Mwd/t received by the uranium. At 10^4 Mwd/t the total surface dose rate from x and gamma radiation should be about 4.3 r/hr after separation. It will increase due to the buildup of Am^{241} and U^{237}; in five days it will be 6 r/hr. The "hard" component is 0.2 r/hr and 1.9 r/hr after five days. This indicates that there is a gain in processing the material quickly. The neutron surface dose rate at 10^4 Mwd/t should be 0.9 r/hr. (auth)

15168 A/CONF.15/P/829

General Motors Corp., Detroit.

NEW LOW ENERGY PHOTON SOURCES FOR INDUSTRIAL UTILIZATION. Farno L. Green and Willard D. Cheek. 13p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Two new photon (x- and gamma-ray) sources, samarium-145 and gadolinium-153, are being evaluated along with Tm^{170} for industrial uses. Sm^{145} and Gd^{153} were reactor-produced by the (n,γ) reaction from enriched stable isotopes. Both are neutron-deficient isotopes decaying by electron capture only; therefore, there is no bremsstrahlung or annihilation radiation. The useful emission from Sm^{145} is an x ray of about 39 kev. Gd^{153} decay gives a 42-key x ray and 70- and 100-kev gammas. Both half lives appear to be about 240 days or longer. These sources can be prepared with high specific activity. No standard radiographic method for comparing low energy photon sources used for inside-out radiography of small objects exists; therefore, a method which is useful is described. Sm^{145} and Gd^{153} sources in some applications are found to be more useful than Tm^{170} for radiography, liquid-level gaging, thickness gaging, and specific gravity measurements. They are also potentially useful for special medical radiography. (auth)

15169 A/CONF.15/P/1071

Knolls Atomic Power Lab., Schenectady, N. Y.

FISSION-PRODUCT RADIOACTIVITY AND HEAT GENERATION. J. R. Stehn and E. F. Clancy. 18p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Graphical and numerical representations of U^{235} fission-product radioactivity were developed for easy and accurate estimations in various applications in reactor technology. The gross fission-product radioactivity is given both for very short and for very long ir-

radiations; and a general theorem allows ready use of these to calculate the radioactivity for irradiations of intermediate length. Nomograms were prepared to facilitate such calculations. An approximation scheme is available for handling cases wherein the reactor power level has varied during irradiation. The radioactivity is broken down into the following types, and representations have been prepared for each: total beta activity (curies), total gamma activity, and gamma activity in each of several ranges of photon energy; total beta power (watts), total gamma power, gamma power in each of several ranges of photon energy, and combined total gamma plus beta power (total heating rate). (auth)

15170 A/CONF.15/P/2390
Atomic Energy Commission, Washington, D. C.
PROGRESS IN THE USE OF ISOTOPES. THE ATOMIC TRIAD—REACTORS, RADIOISOTOPES AND RADIATION. Willard F. Libby. 25p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Recent years have seen a substantial growth in the use of isotopes in medicine, agriculture, and industry. Up to the minute information on the production and use of isotopes in the U.S. is presented. The application of radioisotopes to industrial processes and manufacturing operations has expanded more rapidly than any one except its most ardent advocates expected. New uses and new users are numerous. The adoption by industry of low level counting techniques which make possible the use of carbon-14 and tritium in the control of industrial processes and in certain exploratory and research problems is perhaps most promising of current developments. The latest information on savings to industry will be presented. The medical application of isotopes has continued to develop at a rapid pace. The current trend appears to be in the direction of improvements in technique and the substitution of more effective isotopes for those presently in use. Potential and actual benefits accruing from the use of isotopes in agriculture are reviewed. The various methods of production of radioisotopes are discussed. Not only the present methods but also interesting new possibilities are covered. Although isotopes are but one of the many peaceful uses of the atom, it is the first to pay its way. (auth)

Rare Earths and Rare-earth Compounds

15171 A/CONF.15/P/1425
Bureau of Mines. Rare and Precious Metals Experiment Station, Reno, Nev.
X-RAY SPECTROSCOPY OF RARE-EARTH ELEMENTS. F. W. Lytle, K. R. Stever, and H. H. Heady. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Four applications of x-ray spectroscopy to rare earth research are discussed. A method was developed for the determination of rare earth elements in fractions obtained from bastnaesite and euxenite ores. Yttrium, thorium, and the fourteen rare earth elements may be analyzed in complex mixtures of various concentrations. A rapid method for the qualitative and quantitative analysis of rare earth elements in ion exchange elutriants was developed. Special techniques were developed for determining trace amounts of rare earths in high-purity rare earth oxides produced by ion exchange and by liquid-liquid extraction. A method was developed for quantitative determination of impurities in cerium metal. (W.D.M.)

Shielding

Refer to abstracts 14996 and 14998.

Spectroscopy

15172 A/CONF.15/P/917
Ames Lab., Ames, Iowa. and Iowa State Coll., Ames. Inst. for Atomic Research.
SPECTROGRAPHIC DETERMINATION OF OXYGEN, NITROGEN AND HYDROGEN IN METALS. V. A. Fassel, W. A. Gordon, and R. J. Jasinski. 15p. (ISC-1015). $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The problems encountered in extending conventional spectrographic techniques to the determination of these elements are surveyed, and techniques for surmounting the problems are presented. Methods for the determination of oxygen in steel, titanium, zirconium, niobium, rare earths, and vanadium are discussed. All of the procedures are based on the liberation of the oxygen content of the metal into an argon atmosphere by the high temperatures attained in direct-current arc discharges. Satisfactory gas evolution can be achieved by utilizing a special electrode assembly which provides a molten platinum bath after the arc discharge is initiated. This technique was applied to the determination of oxygen in titanium, zirconium, niobium, and rare earth metals, covering the concentration range from 0.01 to 0.5%. These procedures provide oxygen determinations as accurate as chemical methods and have the advantage of greatly reduced time requirements. The simultaneous evolution of hydrogen and nitrogen with the oxygen was observed for several metal systems. In a d-c arc in argon, the hydrogen Hα line at 6562.8 Å is readily excited. For nitrogen, the CN band radiation at 3883.4 Å is more sensitive than the strongest atomic line at 8216.5 Å. Preliminary results on applying these spectra to the quantitative determination of nitrogen and hydrogen are summarized. (auth)

15173 A/CONF.15/P/943
Argonne National Lab., Lemont, Ill.
X-RAY SPECTROMETRIC ANALYSIS FOR SOME REACTOR FUEL COMPONENTS. D. S. Flikkema, R. V. Schablaske, and R. P. Larson. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

X-ray emission spectrometry has been found adaptable to quick, reliable analysis for several of the fissionable and fission elements in fuel alloys and dilute aqueous solution. This method for milligram quantities of uranium in aqueous solution is in regular use. In sensitivity, reliability, and time requirements, it is comparable to the spectrophotometric methods for uranium, while its freedom from interferences other than from gross concentrations of most other elements makes it notably superior. For plutonium in aqueous solution reliable results are obtained with much smaller amounts than required for the classical methods in use, thus reducing the hazard to personnel from this alpha-emitter. Methods for the direct assay of molybdenum, ruthenium, and zirconium in "fissium" alloys are shown. The more general case of the analytical sensitivity and

reliability of the x-ray method for fission and transition elements in binary compositions with uranium is being examined in a continuing program. (auth)

Theoretical Physics

15174 A/CONF.15/P/386

New York Univ., New York. Inst. of Mathematical Sciences.

HYDROMAGNETIC EQUILIBRIA AND FORCE-FREE FIELDS. H. Grad and H. Rubin. 15p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Solutions of the equilibrium equations of a perfectly conducting fluid (1) div B = 0, grad p = J × B = curl B × B/u are considered. The special case p = constant is a force-free field. These equations are formally identical to those of incompressible fluid flow if B is identified with the fluid velocity and −p with the Bernoulli constant. The solutions of (1) are described by formulating initial and boundary value problems, by integrating the equations in terms of arbitrary functions, and by showing the equivalence with a variational formulation. The situation is complicated by the nonlinearity of the equations. First, one can compute the characteristic normals which are four in number (the system is essentially fourth order). The magnetic lines (analogue—stream lines) are counted twice and there are two pure imaginary roots as for the potential equation. On this basis a number of existence theorems are conjectured (and in some special cases proved). (auth)

Tracer Applications

15175 A/CONF.15/P/2357

Scripps Institution of Oceanography, La Jolla, Calif.

EXPERIMENTS WITH RADIOACTIVE SAND AS A TRACER OF BEACH SAND MOVEMENT. D. L. Inman and T. K. Chamberlain. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The mechanics of sand transportation under the influence of wave action was studied using artificially induced radioactivity in the sand, which effectively tags the sand and does not constitute an apparent health hazard. A sample of naturally occurring quartz sand is taken from the area of study, subjected to slow neutron irradiation, and then reintroduced into the area. The movement of the quartz is traced by sampling the sediment on the bottom and assaying for radioactive particles with photo sensitive paper. In a field experiment, 860 grams of irradiated quartz sand was re-introduced as a point source on the sea floor off Scripps Beach. The experiment showed that the dispersal of sand by wave action was more rapid than expected, and that the movement of this small amount of sand could be followed for about 7 to 24 hours. The irradiated sand was released on the bottom by divers and samples were obtained on a grid at the time intervals of ¼, 1, 3½, 7½, and 24 hours, and several days later. At the point of introduction the water was 10 feet deep and the surface waves were about 1 feet high. The waves caused the sand to spread in an elliptical pattern with an elongate onshore-offshore axis. The sampling indicated that the 860 grams of irradiated fine sand had been dispersed over an area of approximately one square mile in 24 hours. The sensitivity of detection was approximately 1 grain of sand in 100,000. (auth)

Uranium and Uranium Compounds

Refer also to abstracts 14830 and 15156.

15176 A/CONF.15/P/427

Oak Ridge Gaseous Diffusion Plant, Tenn. and Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn.

NUCLEAR SAFETY IN THE UNIRRADIATED PROCESSING PHASES OF ENRICHED URANIUM FUEL CYCLES. J. D. McLendon, J. W. Wachter, and H. F. Henry. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Strict limitations must be imposed on the design and operation of industrial facilities processing fissionable material in order to prevent accidental nuclear chain reactions. Freedom from such criticality hazards can be attained by a program of nuclear safety incorporating geometric, administrative, and operational controls. This paper discusses briefly the fundamental nuclear safety methods common to all uranium processing and considers how, with changing emphasis, these basic rules can be applied to the divergent problems encountered in the unirradiated processing phases of a typical uranium fuel cycle. Such a cycle might incorporate a gaseous diffusion plant, a chemical processing facility, a fuel element fabrication plant and a scrap recovery recycle operation, each of which is characterized by particular criticality problems. This paper is intended to acquaint prospective participants with these unique problems and to indicate the corresponding design criteria and operating procedures which can be applied to achieve nuclear safety in an efficient and effective manner. Experimental criticality data, as presented heretofore, form the basis for the fundamental nuclear safety controls, and the factors considered in adapting such data for production purposes are reviewed briefly. The "safe parameters" thus obtained identify the nuclear variables that enter into every criticality problem, namely, geometry, concentrations of fuel, moderator and poison, reflection, and interaction. Nuclear safety is ensured by establishing control over one or more of these variables and guarding against contingencies arising from possible production mishaps. Illustrative examples and tables summarizing contingencies, possible mishaps and corresponding safeguards for each nuclear variable are presented. The reduction of uranium tetrafluoride to metal and the subsequent handling and processing of enriched metal requires the strict isolation of individual pieces. Means, both mechanical and administrative, of effecting this are discussed. Alloy fuel elements possess the advantages of poorly moderated systems, but require special care in storage and shipping. The treatment of scrap for recycling incorporates all the above problems and presents added difficulties arising from the exceedingly small uranium concentrations. Shipping container designs are discussed which allow a wide range of types and concentrations of enriched uranium materials to be handled safely and economically. (auth)

15177 A/CONF.15/P/615

Knolls Atomic Power Lab., Schenectady, N. Y.

IRRADIATION EFFECTS IN UO_2. W. K. Barney. 11p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The physical, chemical, and mechanical properties of UO_2 that are important in describing irradiation effects are presented. The various types of UO_2 containing

elements studied are discussed along with their relative merits and performances. The irradiation behavior of UO_2 in elements receiving burnups as great as 50% is discussed. Included are such effects as plasticity, fission gas agglomerations and release, sintering, growth or swelling as a function of burnup and crystal structure. An attempt is made to explain these observed irradiation effects based on the UO_2 structure and properties. The advantages and limitations of UO_2 are presented as supported by the irradiation data. (auth)

15178 A/CONF.15/P/618

Sylvania Electric Products Inc., Bayside, N. Y.

MECHANISM OF IRRADIATION-INDUCED DIMENSIONAL INSTABILITY OF URANIUM. L. L. Seigle and L. S. Castleman. 10p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The diffusional theory of growth of uranium under irradiation is critically reviewed in the light of available experimental data. Refinements of the theory are proposed to take into account the most recent methods for computing the rate of generation of lattice defects under irradiation, and the existence of a multiplicity of intracrystalline sites at which surviving lattice point defects can be absorbed. A comparison is made between the diffusional and stress-relaxation theories of irradiation growth, and an attempt made to evaluate the relative positions of the various theories. (auth)

15179 A/CONF.15/P/643

Naval Radiological Defense Lab., San Francisco.

RADIOCHEMICAL STUDIES OF THE FAST NEUTRON FISSION OF U^{235} AND U^{238}. L. R. Bunney, E. M. Scadden, J. O. Abriam, and N. E. Ballou. 7p. $0.50 (OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Radiochemical studies of the fast neutron fission of U^{235} and U^{238} have been made in the mass region beyond mass 143 with two neutron energy distributions. These studies provide measurements of the relative fission yields of several chains in the rare earth group in fission of U^{235} and U^{238} caused by neutrons with an energy distribution very close to unmoderated fission neutrons and by neutrons with an energy distribution peaked at 8 Mev. The increased contribution of very asymmetric modes of fission as the energy of the compound nucleus is increased is clearly shown by the results. In the fission of U^{238} the yield at mass 161 is increased 2.9 times at the higher neutron energy. No previous measurements have been published on radiochemical studies of the fission of U^{238} at these neutron energies beyond mass 144 except at mass 156 for the lower neutron energy. (auth)

15180 A/CONF.15/P/645

Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho.

THE TOTAL AND FISSION CROSS SECTIONS OF U^{233} BELOW 1 KEV. R. G. Fluharty, M. S. Moore, and J. E. Evans. 16p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

A survey of the status of low-energy neutron measurements on U^{233} is presented, with a consistent theoretical analysis of the fission, total, scattering, and eta measurements. This also includes recent MTR cross section measurements. The existence of interference between levels in the fission channels has been established. Since approximate methods are inadequate for the analysis of the fission cross section of U^{233}, the data were fitted in the region below 11 ev, comprising 9 interfering levels, by applying the formalism of Wigner and Eisenbud. The multilevel formula includes barrier penetration factors for the fission process and multiple channels for radiative capture. The assumption that fission is a single channel process in one spin state was made in obtaining the fit, although the formalism can be readily extended to include the effects of several fission channels. This analysis is discussed and compared to single level and approximate two-level approaches. Since the multilevel analysis requires a smaller number of levels to account for the cross section, slightly higher average values for the fission widths and level spacings result. The effect on the strength function is negligible. According to the analysis of the U^{233} cross section, some 90% of the fission at thermal neutron energies is due to resonances which do not interfere with any of the observed levels. This suggests that two different spin states may be present, one involving thermal fission, the other involving fission in the strong resonances. Following this suggestion, the fission product mass distribution was measured radiochemically and found to be different for thermally induced fission as compared to fission induced by neutrons of 1.8 ev, the resonance energy of the first strong U^{233} resonance. Results on additional resonances will be discussed. (auth)

15181 A/CONF.15/P/648

Brookhaven National Lab., Upton, N. Y.

FISSION AND TOTAL CROSS SECTIONS OF U^{235} FROM 0.1 TO 10 EV. F. J. Shore and V. L. Sailor. 21p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The BNL crystal spectrometer has been used to determine both the total and fission cross section of U^{235} in the energy range 0.1 to 10 ev. The fission data were obtained with a multiple plate ionization chamber. Using these total and fission cross sections, and also the scattering data of Foote, both the capture cross section and the variation of alpha with energy are calculated. Analysis of the partial cross sections shows that the shape of the capture resonances is summetrical about E_0, whereas the fission resonances are asymmetrical. This implies interference between levels in the fission process and the need for a multilevel formula in the analysis. Quantitative interpretation of the data is faced with several difficulties: (1) Large backgrounds, apparently due to resonances at negative energy, must be subtracted. (2) The spin state of the nucleus for the various energy levels is unknown. (3) Normalization of fission cross section data includes perhaps a 5% uncertainty originating in the value of σ_f at 0.0254 ev. (4) The proper form of the multilevel formula to use is uncertain. In spite of these difficulties, a better fit to the data is obtained using interference between fission levels than without it. (auth)

15182 A/CONF.15/P/655

Columbia Univ., New York.

LOW ENERGY NEUTRON CROSS SECTIONS OF U^{235} AND THEIR INTERPRETATION. W. W. Havens, Jr. and E. Melkonian. 24p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

Although the neutron properties of U^{235} have been studied extensively, many anomalies still exist both in the experimentally measured quantities and in the interpretation of the results. However, in spite of these anomalies certain general conclusions can be drawn which will probably not be altered by more refined

measurements. The radiative capture widths of the resonance levels in U^{235} appear to behave in the same manner as the capture widths of other nuclei. The capture cross section curve shows symmetrical resonance levels, aside from the 1/v effect, which can be fitted by single-level Breit-Wigner formulas. The measured radiation widths of the few levels which have been studied are the same within the experimental errors, consistent with results on other isotopes. The magnitude of the U^{235} average radiation width is approximately the same as that for neighboring isotopes. The neutron widths of the resonances of U^{235} vary widely, as they do in other isotopes, and follow a Porter-Thomas distribution with $\nu = 1$. One striking feature of these results is that Γ_N^0/D for the first 10 levels is an order of magnitude less than that determined from the remainder of the known resonances. The average Γ_N^0/D has been measured near 1 kev and found to be in good agreement with the latter and also with the strength function of neighboring nuclei. Possible explanations for this anomalously weak set of levels are a statistical fluctuation in the strength function, a non-statistical variation in the average strength function, and resonances other than S-wave resonances. Until the significance of this low energy anomaly is understood, it is not safe to draw conclusions about the behavior of the cross section in any energy region in which it has not been measured. The fission widths of the levels in U^{235} vary widely. A fit to a Porter-Thomas distribution gives $\nu < 4$ and more probably $\nu = 2 \pm 1$, which means that the number of channels available for the fission process is small. Other evidence supports this hypothesis in that the fission cross section for the resonances cannot be fit by assuming the cross section to be the sum of single level resonances. It is necessary to assume substantial interference between resonances to fit the experimental data. Another striking feature of the U^{235} cross section is the rapid rise in the $\sigma\sqrt{E}$ curve, near zero energy, as E decreases. This is attributed to two bound levels at -1.4 and -0.02 ev. One difficulty with this solution is that the level at -1.4 ev must be assumed to be about 30 times as strong as the average level. However, there is some other evidence to indicate that there is such a strong negative energy resonance in that the scattering cross section near zero energy increases above potential scattering with decreasing energy. The accuracy of the radiation widths and fission widths could be increased if the absolute value of the fission cross section of U^{235} were better known. All measurements of the variation of the fission cross section with energy are normalized to the "standard value" at 0.0253 ev. This "standard value" has been measured by several different methods and the results disagree by considerably more than the precision of the measurements. More good experimental results are needed to clarify the observed disagreements. Although the qualitative conclusions stated above appear to be well founded, more accurate determinations of the partial widths of more levels are required in order to be able to calculate more accurate values of the quantities of interest to reactor design. (auth)

15183 A/CONF.15/P/659

Los Alamos Scientific Lab., N. Mex.

A MEASUREMENT OF FISSION THRESHOLD STRUCTURE AND ITS COLLECTIVE MODEL INTERPRETATION. Richard H. Stokes, John A. Northrop, and Keith Boyer. 14p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The results of an experiment using the 14-Mev deuteron beam of the Los Alamos cyclotron to produce (d,p) reactions on fissionable elements are presented. The energy spectrum of the resultant protons is measured for those protons that are in coincidence with fission events. If E_d and ϵ_d are the deuteron kinetic and binding energies, respectively, when the proton and neutron kinetic energies are related by the equation: $E_d - \epsilon_d = E_p + E_n$. It is seen that by measuring the proton energy, the equivalent neutron energy is determined. The energy spectrum of the protons coincident with fission is proportional to the probability for the (d,p) reaction to occur, multiplied by the probability for subsequent fission to take place. In order to obtain a cross section characteristic of the fission process alone, $\sigma_F(E_p)$, the coincident proton spectrum is divided by the total (d,p) proton energy spectrum. A particle identification system was developed to measure these spectra. It allows the whole proton spectrum to be accurately identified in the presence of many elastically scattered deuterons. This system has the necessary properties of a large solid angle and the ability to collect data simultaneously in many channels over a large energy range. The energy and shape of the fission threshold were obtained for U^{233}, U^{235}, and U^{238}. When $\sigma_F(E_p)$ is plotted on a semi-log chart, a straight line of nearly the same slope can be drawn through each of the threshold regions. At a point where $\sigma_F(E_p)$ is one-tenth of its maximum value the U^{233}, U^{235}, and U^{238} curves have neutron energies of -1.3, -1.0, and $+1.3$ Mev, respectively. Published values of neutron separation energies, when combined with the above values, give almost the same value of excitation of the compound nuclei U^{234} and U^{236}, but for U^{239} the value is 0.7 Mev higher. (auth)

15184 A/CONF.15/P/1855

General Electric Co. Hanford Atomic Products Operation, Richland, Wash.

METALLOGRAPHIC STUDIES OF URANIUM. T. K. Bierlein and B. Mastel. 17p. $0.50(OTS).

Prepared for the Second U. N. International Conference on the Peaceful Uses of Atomic Energy, 1958.

The desirability of understanding and predicting the behavior of metallic uranium reactor fuel material as a function of various reactor parameters has warranted a study of the microstructure of non-irradiated and irradiated uranium. Since the metallography of irradiated uranium is difficult and subject to questionable interpretation three different approaches have been used: (1) statistical comparison of the microstructure of non-irradiated uranium with that revealed in irradiated uranium specimens which have been subjected to a standardized sectioning, grinding, polishing, and etching procedure; (2) point to point comparison of non-irradiated areas in metallographic specimens of uranium with the same identical area on the specimen after irradiation; (3) statistical comparison of the fracture surface of notched-bar impact specimens of non-irradiated uranium with that of irradiated uranium specimens. The experimental techniques which include etching by ion bombardment, replication of either flat or rough surfaces, and subsequent optical and electron microscope preparation of the replicas are described. The metallographic data and its interpretation are presented. (auth)

PERSONAL AUTHOR INDEX

This is an index for the reports abstracted in this issue. For each reference the number preceding the dash is the volume number and the number after the dash is the abstract number. Personal author indexes are cumulated on a semiannual and annual basis.

A

ABRAHAM R M
12-14605
ABRAM J O
12-14720 12-15179
ACKERMANN R J
12-14608
ADAMS R M
12-14635 12-14813
ADAMSON G M JR
12-14837
ADER M
12-14812
ADLER F T
12-14956
ADLER HANS H
12-14781
ADOLPH NORMAN R
12-14614
AEBERSOLD PAUL C
12-14928
AIKAWA JERRY K
12-14595
ALBRECHT W M
12-14736
ALBRIDGE R G JR
12-14966
ALBRIGHT LYLE F
12-14657
ALINE P G
12-15026
ALLEN AUGUSTINE O
12-14654
ALLEN K A
12-14678
ALLEN R J
12-14729
ALLEN W O JR
12-15034
ALVAREZ LUIS W
12-14917
AMES L L JR
12-14745
ANDERSEN R V
12-14523
ANDERSEN R K
12-14983
ANDERSON A O
12-14548
ANDERSON D
12-14899
ANDERSON J M
12-14487
ANDERSON OSCAR A
12-14869 12-14890
ANGER HAL O
12-14548 12-14599
ANNO J N
12-14990
ARCHBOLD NORBERT L
12-14776
ARMSTRONG E L
12-15101
ARMSTRONG R H
12-14991 12-15052
ARNOLD D S
12-14738
ARNOLD E D
12-15075
ARNOLD H
12-15076
ARNOLD JAMES R
12-14771 12-14772
ARVIA A J
12-14647
ASHMORE JAMES
12-14564
ASPREY L B
12-14725
AUERBACH S I
12-14554
AUERBACH T
12-14992
AVERY R
12-14841 12-15082
12-15099
AVERY ROBERT T
12-14547
AWOROSI A
12-15125
AYERS A L
12-14903
AYRES J A
12-14769

B

BABB A L
12-15066
BABCOCK DALE E
12-15029
BAES C F JR
12-14705
BAGNALL H J
12-14546
BAILES R H
12-14668
BAILEY R M
12-14628
BAILEY R E
12-15114
BAILY NORMAN A
12-15165
BAIR W J
12-14512
BAKER D A
12-14879
BAKER D D
12-14796
BAKER D H JR
12-14818
BAKER F B
12-14782
BAKER P S
12-14905
BAKER R D
12-14639 12-14708
BAKER WILFRED E
12-15053
BAKER WILLIAM R
12-14869 12-14880
12-14890
BALDWIN LOUIS
12-14542
BALF WILLIAM F
12-14580
BALESTRACCI O P
12-15086
BALLANTINE D S
12-14646
BALLOU N E
12-14720 12-15179
BANE R W
12-14625
BANKS CHARLES V
12-14621
BARBER E J
12-14701
BARFIS D W
12-14665
BARFISS ERWIN H
12-14907
BARLOW CHARLES F
12-14571
BARNARD J
12-14982
BARNES A H
12-14758
BARNES BENJAMIN A
12-14587
BARNES J W
12-14815
BARNES R F
12-14974
BARNETT C F
12-14845 12-14942
BARNETT P R
12-14783
BARNETT R H
12-14791
BARNEY W K
12-15177
BARR FRANK T
12-14645
BARR N
12-14921
BARTNOFF S
12-15106
BARTZ M H
12-15085
BASS H N
12-14981
BASSHAM JAMES A
12-14487 12-14567
BATE L C
12-14623
BATES THOMAS F
12-14792
BATZER O F
12-14488
BAUER A A
12-14816 12-14895
BAUM J W
12-14615 12-14659
BAXTER EDMUND F JR
12-14658
BEALL S F
12-15003
BEAMS J W
12-14698
BEAUCHAMP E F
12-14699
BEAVER R J
12-15093
BERRINGTON WILLIAM P
12-14629
BECK C K
12-15122
BECKJORD E
12-15092
BELL GEORGE I
12-14909
BELL K G
12-14737
BELL P R
12-14845
BELL W A JR
12-14905
BELLE J
12-14743
BELMORE E A
12-14904
BEMIS F A
12-14796
BENEDICT MANSON
12-15050
BENGSTON J
12-15074
BENNETT E L
12-14486
BENNETT G A
12-14812
BENNETT L
12-14493
BENNETT W H
12-15142
BENSON A A
12-14619
BENSON D W
12-14571
BENTLE G G
12-14819 12-15030
BENVENISTE JACOB
12-14958
BENZ R
12-14811
BERGER J M
12-14856 12-14862
BERKOWITZ J
12-14871 12-14881
BERMAN ABRAHAM S
12-14755 12-14900
BERNHARDT H A
12-14656 12-14701
BERNSTEIN G
12-15014
BERNSTEIN I R
12-14862
BERNSTEIN W
12-14857
BETTERTON J O JR
12-14837
BEVERLY R G
12-14680
BEYER F C
12-15068
BIEHL A T
12-15124
BIERLEIN T K
12-15184
BIGELEISEN JACOB
12-14609
BILLS C W
12-14803
BING G
12-14876
BING P J
12-14589
BISKIS BIRUTE O
12-14505
BJORKLUND C W
12-14721 12-14811
BJORKLUND FRANK
12-15149
BLACK A L
12-14557
BLACK JAMES F
12-14658
BLACK KATHLEEN M
12-14679
BLAHD WILLIAM H
12-14586
BLAIR HENRY A
12-14510
BLAKE C A JR
12-14677 12-14705
BLANCHARD R L
12-14617
BLANCO R E
12-14712
BLANKENSHIP F F
12-15002
BLASEWITZ A G
12-14746
BLASS U
12-14487
BLATZ H
12-14521
BLAU MONTE
12-14583
BLEIBERG M L
12-15155
BLIZARD EVERITT P
12-15100
BLOCHER J M JR
12-14766
BLOCK F F
12-14695 12-14817
BLOCK R C
12-14972
BLOMEKE J O
12-14747
BLOOMSTER C H
12-14830
BLUE D D
12-14818
BOHL L S
12-14945 12-15074
BOLAND J F
12-15079
BOLLINGER LOWELL M
12-14960 12-14974
12-14975
BOLT ROBERT O
12-15162
BOND V P
12-14491 12-14565
BONDELID R O
12-14973
BORG DONALD C
12-14618
BORN J L
12-14548
BORROWMAN S R
12-14672
BOSTICK WILLIAM H
12-14866
BOURDEAU R A
12-15040
BOURDEAU R G
12-15152
BOWEN V T
12-14555 12-14770
BOWERSOX D F
12-14811
BOWMAN HARRY R
12-15130
BOYER C B
12-14825
BOYER KEITH
12-15183
BOYER W H
12-14802
BOYESEN S
12-14944
BOYLE T L
12-14780
BRADNER HUGH
12-14918 12-14919
BRAND G F
12-14833
BRANYAN C E
12-15023 12-15099
BRATENAHL ALEXANDER
12-14869
BRATER D C
12-14731 12-14732
BRAUN C R
12-15006
BRECHER G
12-14565 12-14592
BREDEN C R
12-14768
BREEN R J
12-15022
BRESEE J C
12-14700
BRIANT R C
12-15027
BRIGGS H D
12-14760
BRITTAN R O
12-14998 12-15079
12-15098
BRODSKY H R
12-15009
BRODY JAMES K
12-14625 12-14901
BROLLEY J E JR
12-15150
BROOKSBANK R E
12-14691
BROOKSBANK W A JR
12-14629
BROSI A R
12-14693
BROUNS R J
12-14626
BROWER D F
12-14852
BROWN DARRELL O
12-14939
BROWN GEORGE C
12-15165
BROWN J R
12-15076
BROWN F B
12-14677 12-14678
12-14705
BROWN R F
12-14761
BROWN S C
12-14878
BROWN W W
12-15020

BROWNELL GORDON L
12-14545 12-14547
BROWNELL L E
12-14541
BRUCE F R
12-14691
BRUCER M
12-14550
BRUNSON G S
12-15023 12-15074
12-15099
BRYNER J S
12-15009
BUCHANAN JOHN
12-14596
BUCHANAN R F
12-15069 12-15127
BUGHER JOHN C
12-14531
BUMP T R
12-15007
BUNNEY L R
12-14720 12-15179
BURCH W D
12-15003
BURDICK A R
12-14495
BURKHARDT L C
12-14893
BURNETT C R
12-14858
BURNS R E
12-14733 12-14748
BURNS R T
12-14519
BURR JOHN G
12-14665 12-14718
BURRIS L
12-14812
BURTON MILTON
12-14649
BUSH P D
12-14982
BUTLER ARTHUR P JR
12-14787
BUTLER D K
12-15072
BUTLER J W
12-14850
BYRNE J R
12-14669

C

CALDECOTT RICHARD S
12-14489
CALKINS G D
12-14932
CALVIN MELVIN
12-14486 12-14487
CAMPANA R J
12-14994
CAMPBELL I E
12-14766
CAMPBELL JAMES P
12-14544
CAMPBELL R W
12-15004
CANNON R S JR
12-14778
CARLSON RENGT G
12-14909
CARLSON R D
12-14605
CARLSON T A
12-14709
CAROTHERS J E
12-15074
CARPENTER F D
12-14826
CARR W H
12-14690
CARROLL J L
12-14733
CARROLL JAMES G
12-15162
CARSON N J
12-15046
CARSTEN ARLAND L
12-14510
CARTER J C
12-15079
CARTER R E
12-14961
CARTER R L
12-15039
CASARETT GEORGE W
12-14510
CASEY R D
12-14804
CASSEN BENEDICT
12-14588
CASTER W O
12-14500
CASTLEMAN L S
12-15178
CASWELL R S
12-14951
CATHERS G I
12-14690
CEGELSKI W M
12-14983
CEMBER HERMAN
12-14498
CHAMBERLAIN T K
12-15175
CHARLES W D
12-14680
CHASE H B
12-14507
CHASTAIN J W
12-14990
CHAVE C T
12-15086
CHECK WILLARD D
12-15168
CHELLEW N R
12-14812
CHEN F F
12-14857
CHERNICK J
12-14955 12-14992
CHESTER C V
12-14700
CHEW GEOFFREY F
12-14963
CHILENSKAS A A
12-14812
CHIN J
12-14951
CHIOTTI PREMO
12-14809
CHISWIK H H
12-14823
CHORNEY W
12-14578
CHOW J G Y
12-15121
CHOW T
12-14806
CHRISTIE W H
12-14699
CHRISTOFILOS N C
12-14896
CHUNG A C
12-14558
CHUPP MARY M
12-14492
CHURCHILL S W
12-15074
CLANCY F F
12-15169
CLEMENTE C D
12-14499
CLEMMER J R
12-14672
CLINE J F
12-14516
CLUKEY H V
12-14523
COCHRAN R G
12-15056
COE R J
12-15055
COENSGEN F H
12-14872
COFFIN C T
12-14965
COFFINBERRY A S
12-14950
COHEN E RICHARD
12-14954 12-15033
COHEN JONATHAN
12-14596
COHEN K P
12-15026
COHEN P
12-14980
COHN C E
12-15024 12-15099
COLE T E
12-14988
COLEMAN C F
12-14677 12-14678
12-14705
COLEMAN E W
12-14541
COLEMAN L F
12-15014
COLGATE S A
12-14867 12-14868
12-14880
COLVEN T J
12-14685
COLVIN T H
12-14993
CONARD R A
12-14491
CONDON C C
12-14530
CONNER J P
12-14897
CONNOR J C
12-15077
COORS J H
12-14836
COOK M J
12-14525
COON J H
12-14969
COOPER V R
12-14714
COOR T
12-14861
CORBETT J W
12-15163
CORLISS L M
12-14844
CORNGOLD N
12-14955 12-15109
CORZINE P
12-15043
COTE R E
12-14974 12-14975
COWAN C L JR
12-14961
COWAN F P
12-14518
COWAN GEORGE A
12-14764
COWSER K E
12-14750 12-14751
COX J A
12-14988
COX S
12-15137
CRAIG HARMON
12-14805
CRAMER E M
12-14810
CRANDALL PAUL
12-14588
CRANE WILLIAM W T
12-14710
CRAWFORD J H JR
12-14765
CREEK GEORGE E
12-15060
CRESPI H L
12-14578
CROMPTON C E
12-14741
CRONKITE E P
12-14491 12-14565
12-14592
CROSSLEY D A JR
12-14554
CROUSE D J
12-14677
CULLER F L
12-14712
CUNNINGHAM J E
12-15093
CUNNINGHAM S P
12-14852 12-14861
CURTIS HOWARD J
12-14506
CUTHBERT F L
12-14741

D

DARRS J W T
12-15139
DAMASK A C
12-15153
DAMM C C
12-14873
DANFORTH J P
12-14902
DANIELS E W
12-14502
DANIELS R S
12-14513
DARE W L
12-14795
DAVIDSON J M
12-14636
DAVIS F T
12-14681
DAVIS J J
12-14516
DAVIS J O
12-14741
DAVIS W C
12-14905
DAVIS W JR
12-14656 12-14701
DAVIS W KENNETH
12-14476
DAWSON J M
12-14856
DAY EUGENE D
12-14583
DE HALAS D R
12-14606
DE LAGUNA W
12-14750 12-14761
DEARWATER J R
12-14752
DEAVER R S JR
12-14934
DEBOISBLANC D R
12-15054 12-15077
DEEGAN G E
12-15004
DEL CAMPO A R
12-14984
DELWICHE C C
12-15164
DENKO JOANNE D
12-14529
DEPACKH D C
12-15144
DESESA M A
12-14674 12-14675
DESHONG J A JR
12-15114
DESSAUER G
12-15015
DEVAN J H
12-14836
DEWES R A
12-14760
DIAMOND H
12-14974
DICKERMAN E
12-14674
DICKSON R F
12-14991
DIENES G J
12-14638 12-15153
DIJKSTRA L J
12-14826
DILLON R L
12-14769
DIVEN R C
12-14970
DOAN R L
12-15104
DOBSON P LOWRY
12-14492
DODD P H
12-14797 12-14799
DOE W R
12-15127
DOERNER R C
12-15068
DOETSCH P H
12-14558
DOHERTY D G
12-14530
DOLF MALCOLM
12-14647
DOMEK N S
12-14571
DONDES S
12-14655 12-14999
DONNELL ALTON P
12-15081
DOOLEY J RAY JR
12-14927
DOTY D M
12-14488
DOUDNEY C O
12-14496
DOUGLAS D A
12-14836
DOWDY ANDREW H
12-14581
DRALEY J F
12-14768
DRICER H
12-14888
DRIESNER A R
12-14697
DROULLARD R F
12-14797
DRUMMOND JAMES E
12-14877
DRURY J S
12-14604
DRUSCHEL R E
12-14623
DUFFIELD ROBERT R
12-15051 12-15195
DUNAWAY R E
12-14852
DUNHAM C L
12-14549
DURRIN PATRICIA
12-14527
DUTTACHOUNDHURY J
12-14589
DWIGHT A E
12-14823
DWYER D E
12-14834
DYKSTRA J
12-14630
DYSON F J
12-15051

E

EASTERDAY O D
12-14546
EATHERLY W P
12-15040
ERY F S
12-14873
EDER H A
12-14594
EDLUND M C
12-15120
EGAN J J
12-14704
EHRET C F
12-14903
EHRLICH R
12-15078
EICHELBERGER R L
12-15039
EICHLER E
12-14971
EISENBUD M
12-14521
ELLINGER F H
12-14721
ELLIOTT N
12-14844
ELLIOTT V A
12-15110
ELLIS D A
12-14669 12-14729
ELLIS R A
12-14861
ELMORE W C
12-14855
EMERY J F
12-14623
EPSTEIN RITA H
12-14996
ERGEN WILLIAM KRASNY
12-15032
ERKES PIERRE
12-14984
ESCHBACH F A
12-15059
ESHAYA A M
12-14834
ESSELMAN W H
12-15005
EVANS J E
12-15180
EVERHART D L
12-14800

F

FAGEN W F
12-15096
FAILLA GIOACCHINO
12-14610
FAIRHALL A W
12-15134
FARIS F E
12-15004
FARR L E
12-14566
FASSEL V A
12-15172
FAST F
12-15077
FAX D H
12-15106 12-15111
FEDER HAROLD M
12-14812 12-14814
FELLER D D
12-14574
FELLOWS JOHN A
12-14891
FENG P Y
12-14691
FERGUSON J P
12-14867 12-14868
FERNBACH SYDNEY
12-15149
FIELDS MAX
12-14581
FIELDS P
12-15137
FINCH C A
12-14976
FINKEL A J
12-14578
FINKEL MIRIAM P
12-14505
FINKELSTEIN D
12-15148
FIRSCHEIN H E
12-14562

FISCHER D
12-15092
FISCHER D L
12-14981
FISCHER G F
12-15099
FISCHER G J
12-14813 12-15074
FISCHER P L
12-15115
FISHER RAY W
12-14829
FITCH S H
12-15065
FITE W L
12-14868
FITZGERALD P J
12-14539
FLEISCHER SIDNEY
12-14563
FLIEGNER T M
12-14565
FLIKKEMA D S
12-15173
FLINN W S
12-14757
FLORA J W
12-15066 12-15067
FLOTOW H E
12-14605
FLUHARTY R G
12-15180
FOLTZ J R
12-14833
FORBES S G
12-15126
FORD E C
12-14872
FOSTER D G JR
12-14957
FOWLER E EUGENE
12-14928
FOWLER WILLIAM A
12-14843
FOX C J
12-14541
FOX J P JR
12-14688
FRANCIS N C
12-14945
FREDRICKSON R A
12-15005
FRENCH N R
12-14538
FRESHLEY M D
12-14832
FREUND G A
12-15080
FRICKE HUGO
12-14648
FRIED SHERMAN
12-14613
FRIED WALTER
12-14569
FRIEDELL HYMER L
12-14601
FRIEDMAN A
12-15137
FRIEDRICHS K O
12-14881
FRIEMAN E A
12-14856 12-14862
12-14885
FRIES R A
12-14592
FRISKE W H
12-14828
FROHN L W
12-15089
FRONDEL CLIFFORD
12-14807
FROST R T
12-15071
FRYAR R M
12-15001
FRYE J H JR
12-14837
FULLHART CHARLES R
12-14829
FUQUA P A
12-14551
FUQUAY JAMES J
12-14515 12-14604
FURTH H P
12-14867 12-14868
12-14869
FURTH J
12-14491

G

GARFLMAN JOHN W
12-14802
GARRIO BEVERLY W
12-14576
GALANTER L
12-15159
GAMBLE D P
12-15064
GARBER H J
12-15111
GARCIA J F
12-14600
GARDNER C S
12-14870
GARDNER E L
12-15064
GARDNER H E
12-14674
GARDNER H H
12-14890
GARREN A
12-14876
GARRETT G A
12-14727
GATES DUANE C
12-14899
GEBHARD K L
12-14506
GECKLER R P
12-15174
GEIER R G
12-14683
GELBARD E M
12-15078
GELLER L
12-14891 12-14996
GENNA S
12-14921
GENS T A
12-14633
GERBER R C
12-15028
GERCKE R H J
12-14665
GHIORSO ALBERT
12-15141
GIBERSON RICHARD C
12-15162
GIBSON G
12-14874
GIDEZ L I
12-14594
GILBREATH J R
12-15156
GINELL W S
12-14704
GLASER D A
12-14919
GLASGOW L E
12-15004
GLASS B A
12-14934
GLATTER J
12-15115
GLINES A
12-14646
GODWIN P P
12-14474
GOERTZ R C
12-14535 12-14642
GOERTZEL H
12-14870 12-14881
GOLDBERG EDWARD D
12-14806
GOLDMAN K M
12-14835
GOLDMAN L M
12-14863
GOLDMAN M I
12-14519
GOLDSMITH M
12-15112
GOLDSTEIN HERBERT
12-14957
GOLDWASSER EUGENE
12-14569
GOMBERG HENRY J
12-14997
GOODALE E E
12-14760
GOODLAND RUTH L
12-14580
GOODMAN CLARK
12-15061
GORDON P R
12-15028
GORDON SHEFFIELD
12-14662
GORDON W A
12-15172
GORING G
12-14813
GOTTFRIED DAVID
12-14774
GOTTLIER M R
12-14863
GOW JAMES DONALD
12-14920
GRAAF J
12-15014
GRAD H
12-14870 12-14871
12-14881 12-14882
12-15174
GRAF PETER
12-14619
GRAHN DOUGLAS
12-14501
GRANQUIST D P
12-15059
GRANT N R
12-14768
GRAVES GLEN A
12-15058
GREFFLER P
12-15103
GREEN A F S
12-14967
GREEN FARNO L
12-14902 12-15168
GREEN J L
12-14640
GREEN S J
12-15005
GREYNER HOWARD D
12-14895
GRIFFITH W L
12-14726
GRIFFITTS W R
12-14785
GRIMARUD L
12-15066
GRIMES W R
12-15002
GRIMMETT E S
12-14762
GRODZINS L
12-14914
GROVE D J
12-14858
GRUEN DIETER M
12-14613
GUILD WARREN
12-14596
GUNST S R
12-15077
GUNTHER RALPH L
12-14508
GURINSKY D H
12-15010 12-15121
GURNEY CLIFFORD W
12-14569
GUTTE J O
12-14557
GWIN R
12-15018

H

HAAS F L
12-14496
HAERTLER G J
12-15078
HAGEN CAL E
12-14597
HAGERMAN D C
12-14897
HALL D R
12-15097
HALL V C
12-15114
HALPERIN J
12-14978
HALPERN I
12-14965
HAMILL WILLIAM H
12-14649
HAMILTON W C
12-14844
HAMMER C L
12-15143
HANPSON D C
12-15014
HAN JOON TAIK
12-14933
HAND R
12-14581
HANDLOSER J S
12-14930
HANSEN GORDON E
12-15017 12-15058
HANSEN W N
12-14893
HANSON GLEN E
12-14681
HANSON WAYNE C
12-14516 12-14551
HARKER W H
12-15103
HARPER PAUL V
12-14542 12-14543
12-14585
HARRER J M
12-15114
HARRIMAN J W
12-15109
HARRINGTON ROBERT
12-15162
HARRIS I
12-14976
HARRISON VENTON R
12-14560
HART EDWIN J
12-14653 12-14662
12-14663 12-14991
12-15042
HART J M
12-14828
HART OLIN M
12-14793
HARTECK P
12-14655 12-14999
HARTWELL ROBERT W
12-15081
HARVEY BERNARD G
12-15140
HARVEY J A
12-14972
HARVEY M
12-15124
HARVEY R A
12-14911
HASSIALIS M D
12-14702
HASTERLIK R J
12-14578
HASTINGS A RAIRD
12-14564
HASTINGS J M
12-14844
HATCH A J
12-14850 12-14851
HATCHER A P
12-14876
HAUROWITZ FELIX
12-14563
HAVENS W W JR
12-15182
HAYWARD R R
12-15030 12-15043
HAZEN W C
12-14639
HEAD E L
12-14721
HEAD M A
12-15092
HEADY H H
12-15171
HEALD M A
12-14857 12-14861
HEALY JOHN W
12-14515 12-14529
12-14551 12-14616
HEAP J C
12-14998
HEATON LEROY
12-14915
HECHT LISELOTTE I
12-14568
HEIM A H
12-14560
HEINEMAN A H
12-15089
HEINEMAN J B
12-14991
HEINEMAN R F
12-15095
HEINMETS F
12-14885
HEINZ O
12-14875
HELLENS R L
12-15076
HELMICK MARIE
12-14596
HEMMENDINGER A
12-14968
HENDRICKS STERLING B
12-14597
HENDRIE J M
12-14943 12-15109
HENLEY R
12-15124
HENLINE P W
12-14738
HENNES A R
12-14594
HENNIG G R
12-14638
HENRICH L R
12-14876
HENRICKSON A V
12-14639
HENRIE J O
12-15067
HENRY H F
12-15176
HERRON D P
12-15057
HERSCHMAN A
12-14885
HESS WALTER C
12-14560
HETRICK D L
12-15064
HIBBS R F
12-14726
HIRDON CARL T
12-15151
HIGGINS GARY H
12-14710
HIGGINS I R
12-14676
HILBERRY NORMAN
12-15128
HILL D L
12-15131
HILL D R
12-14796
HILL F B
12-14834
HILPERT L S
12-14788
HINDMAN J C
12-14667
HINMAN G W
12-14956
HOAGLAND MAHLON B
12-14568
HODGE F S
12-14825
HODGE HAROLD C
12-14520
HOECKER FRANK E
12-14602 12-14933
HOEKSTRA HENRY R
12-14739
HOFMANN P L
12-15116
HOFSTADTER ROBERT
12-14962
HOGANCAMP C E
12-14589
HOGLUND B H
12-14757
HOLDEN ROBERT B
12-14696
HOLLAND J Z
12-14941
HOLLAND L K
12-15092
HOLLANDER J M
12-14966
HOLLEY C F JR
12-14721
HOLM-HANSEN O
12-14486 12-14487
HOLMES D K
12-15163
HOMFISTER O E
12-15047
HONDA M
12-14772
HONSAKER J L
12-14897
HONSTEAD J F
12-14749
HOPKINS G R
12-15077
HORTON J H JR
12-14761
HOSLER C R
12-14939
HOWARD J C
12-14875
HOWLAND JOE W
12-14510
HUBER A P
12-14630
HUBER E J JR
12-14721
HUENNEKENS F M
12-14576
HUGHES A M
12-14486
HUGHES D J
12-14977
HUGHES W L
12-14566
HUIZENGA J R
12-15136
HULL D E
12-14532 12-14756
HUMMEL H H
12-15024 12-15099
HUMPHREYS J R JR
12-15091
HURFORD W J
12-14828 12-15044
12-15115
HURSH JOHN B
12-14510

HUSTON N E
12-15065
HUTTER F
12-15073

I

IDA N
12-14820
ILLSLEY C T
12-14803
IMHOF WILLIAM
12-14936
IMMAN D L
12-15175
INOUYE H
12-14836
IRONSIDE WILLIAM M S
12-14549
ISE JOHN JR
12-14869 12-14890
ISKENDERIAN H P
12-15080
ISLER R J
12-15008
IZZO T F
12-14671

J

JACOBSON LEON O
12-14569
JAFFEE R I
12-14822
JAMIESON C P
12-15077
JANES M
12-15040
JANKOWSKI F J
12-15117
JANKUS V Z
12-15102
JANSSEN E
12-14983
JAROSLOW R N
12-14504
JAROSS ROBERT A
12-14758 12-14759
JASINSKI R J
12-15073
JASTROW R
12-14976
JEFFERIES J M
12-14830
JENKINS THOMAS L
12-14899
JENSEN R C
12-15134
JOHNSON A CONNOR
12-14484
JOHNSON D
12-14584
JOHNSON D H
12-15004
JOHNSON J C
12-14798
JOHNSON J L
12-14869 12-14885
JOHNSON J S
12-14709
JOHNSON K W R
12-14811
JOHNSON KENNETH P
12-14473
JOHNSON N R
12-14971
JOHNSON W E
12-15106 12-15111
JONES HARDIN
12-14527
JONES R T
12-15112
JONKE A A
12-14706 12-14734
12-14762
JOWSEY JENIFER
12-14501
JULIENS J
12-14992

K

KADE H
12-14584
KAHLE W
12-14546
KALDA D C
12-14752
KALKWARF D R
12-14660
KAMMERER O F
12-15121
KAPLAN S
12-15112
KARNOVSKY MANFRED L
12-14575
KARR H J
12-14897
KARRAKER D G
12-14686
KASS S
12-14835
KASSCHAU K
12-15094
KATO H
12-14817
KATO W Y
12-15024 12-15072
12-15099
KATZ J J
12-14578 12-14635
KAUFMANN S G
12-15074
KEENAN T K
12-14725
KEENE A R
12-14526
KEILHOLTZ G W
12-15002
KELBER C N
12-14991 12-15052
KELLER ELIZABETH B
12-14568
KELLS MILTON C
12-14696
KELLY LOLA S
12-14590
KENNEDY C A
12-14973
KENNEY ROBERT W
12-14899 12-14936
KEREIAKES J G
12-14840
KERR P F
12-14773
KERR WILLIAM
12-14475
KERST D W
12-14852
KESSIE R W
12-14706
KETCHUM R H
12-14555
KETRON C V
12-14905
KEYS W S
12-14799
KIEHN R M
12-15000
KIGOSHI K
12-14624
KILLEEN J
12-14881
KILLELEA J R
12-14702
KILSBY F R
12-14982
KING R W
12-14932
KING BLAKE
12-14820
KING L D P
12-15000
KIRCHER J F
12-14932
KIRN F S
12-15023 12-15099
KIRSCH M
12-14589
KITTEL J H
12-15127 12-15160
KLAMUT C J
12-15121
KLEIBER MAX
12-14557
KLEIN A W
12-15044
KLEIN D
12-15076
KLOPP W D
12-14822
KLOVERSTROM F A
12-15074
KMETKO E A
12-14637
KNAPP EDWARD A
12-14936
KNIGHTON J R
12-14812
KNOX WILLIAM J
12-14754
KOCH H W
12-14931
KOCH L J
12-15073
KOCZY F F
12-14808
KOEHL R G
12-14736
KOEHLER J S
12-15163
KOLB A C
12-14846
KOLB W L
12-15052
KOMOTO T T
12-15074
KORNBERG H A
12-14514 12-14593
KORNBLITH L JR
12-15092
KOSHLAND D E JR
12-14572
KOSIBA W
12-14638
KOSKI WALTER S
12-14651
KOSLOV S
12-14891
KOUTS H J C
12-15010 12-15076
KOUTZ STANLEY L
12-15051
KRALIK R J
12-14904
KRAMER H P
12-14534
KRANZ A Z
12-14857 12-14861
KRATCHMAN JACK
12-14801
KRAUS K A
12-14709
KREBS A T
12-14840
KRIEGER T J
12-14945
KRUSKAL M D
12-14863 12-14864
12-14886
KRYSHTAL L
12-14542
KUHL D
12-15159
KUHLTHAU A R
12-14698
KULSRUD R M
12-14856 12-14862
12-14885 12-14886
KUNKEL W R
12-14869
KUNKEL WULF R
12-14890
KUPER J R H
12-14518
KUPP R W
12-14861

L

LA GRANGE L D
12-14826
LA MER VICTOR K
12-14670
LAKSHMANAN S
12-14558
LAMB E
12-14699
LAMB W A S
12-14874
LANZL LAWRENCE H
12-14547
LAROCCO M J
12-14983
LARSEN ESPER S JR
12-14774
LARSEN R P
12-14762 12-15173
LASLETT L JACKSON
12-15143
LASZLO DANIEL
12-14552
LATHROP KATHERINE A
12-14542 12-14585
LAURENSTEIN R A
12-15019
LAUDERDALE R A
12-14513
LAUER E J
12-14874
LAUGHLIN J S
12-14921
LAVIA MARIANO F
12-14529
LAWRENCE J H
12-14600
LAWRENCE J N P
12-14742
LAWROSKI S
12-14706 12-14734
12-14762 12-14812
LAZARUS DAVID
12-14838
LAZARUS R B
12-14993
LEACHMAN R B
12-15132
LEARY J A
12-14708 12-14811
LEDDICOTTE G W
12-14617 12-14629
LEE C E
12-14906
LEE L L JR
12-14960
LEESER D O
12-14816 12-15047
LEFEBVRE F C
12-14558
LELLOUCHE G
12-14992
LEMMON RICHARD M
12-14650
LEMON R B
12-14689
LENARD A
12-14856
LENNOX D H
12-15052
LEONARD B P JR
12-14517
LEONE CHARLES A
12-14648
LESTER W JR
12-14578
LEVENSON M
12-14707 12-15014
12-15073
LEVIN GILBERT V
12-14560
LEVIN S A
12-14697 12-14727
LEVINE H D
12-14521
LEVINE N
12-14702
LEVINE S H
12-15021
LEVITZ N
12-14706 12-14734
LEVY S
12-15026
LEWIS MILTON
12-15059
LEWIS W B
12-14903
LEWIS W H
12-14692
LIBBY RAYMOND L
12-14581
LIBBY WILLARD F
12-15170
LIEBENTHAL JOHN L
12-14657
LIEBERMAN JOSEPH A
12-14749
LIETZE ARTHUR
12-14563
LIIMATAINEN R C
12-14706
LILLIE D W
12-14666
LINDAUER R B
12-14690
LINDBLOM R A
12-14796
LINDBLOM ROBERT O
12-14650
LINDSETH ELMER L
12-14477
LINK L E
12-14991
LIPPINCOTT S W
12-14491
LITTLE E M
12-14855
LITTLEFIELD JOHN W
12-14568
LITTY A H F
12-14706
LLOYD L T
12-14823
LORSINGER R J
12-14769
LOEDING J W
12-14762
LOEWENSTEIN W B
12-15023 12-15037
LOFSTROM J E
12-14499
LOFTFIELD ROBERT B
12-14568
LONBERG-HOLM K K
12-14486 12-14547
LONG J K
12-15023
LONG R S
12-14669 12-14720
LONGMIRE CONRAD L
12-14884
LOOMIS C C
12-15050
LOONEY W R
12-14596
LOSCO E F
12-15115
LOTTES P A
12-14757
LOVBERG R H
12-14893
LOVE L O
12-14905
LOVE T A
12-15133
LOVOFF A
12-15073
LOWDER W M
12-14521
LUCE J S
12-14845 12-14881
LUCKOW WILLIAM F
12-14908 12-15074
LUFTHY E
12-14589
LUICK J R
12-14557
LUND L M
12-14900
LUPFER D A
12-14842
LYON J P
12-15104
LYON W L
12-14694
LYTLE F W
12-15171

M

MACGREGOR MALCOLM H
12-14979 12-15144
MACHEREY ROBERT F
12-15045 12-15046
MACHTA LESTER
12-14940
MACINTYRE WILLIAM J
12-14601
MACK R E
12-14589
MACKEVETT E M JR
12-14775
MACKLIN L
12-15012
MACKLIN R L
12-14949
MACOMBER M
12-14756
MACPHERSON H G
12-15027
MAGEE JOHN L
12-14649
MAGNER J E
12-14668 12-14729
MAGNO P J
12-14674
MAINSCHEIN F C
12-15133
MAKINODAN T
12-14550
MALETSKOS C J
12-14596
MALLOY MARJORIE
12-14774
MALM JOHN G
12-14634
MALMBERG J H
12-14852
MALOTT W M
12-14982
MANDIL I H
12-15005
MANLY W D
12-14836
MANN M M
12-15122
MANN WILFRID B
12-15166
MANOWITZ B
12-15150

PERSONAL AUTHOR INDEX

MANSFIELD R L
12-15040
MARAMAN W J
12-14643 12-14719
12-14811
MARCHATERRE J F
12-14757
MARKOWITZ J M
12-14821
MARKS S
12-14512
MARSDEN R S
12-15054
MARSHALL JOHN
12-14854
MARSHALL JOHN H
12-14591
MARTENS F H
12-15024 12-15068
MARTIN G R
12-14562
MARTIN J A
12-14905
MARTIN W J
12-14972
MARTINO M A
12-14953
MASH D R
12-15057
MASON F A
12-14673
MASTEL R
12-15184
MASTRAN J L
12-15145
MATHER J W
12-14892
MATHESON MAX S
12-14652 12-14661
MATLACK GEORGE M
12-14622
MATTERN K L
12-14833
MAUSTELLER J W
12-14994
MAXSON R D
12-15110
MAXWELL WILLIAM A
12-14820
MAYER KARL M
12-14478
MAYNARD E H
12-14495
MCADAMS W A
12-14522
MCARTH ROBERT L
12-14613
MCCARTHY W J JR
12-15102
MCCUAIG F D
12-15046
MCCULLOUGH C ROGERS
12-15070
MCDANIEL W N
12-15047
MCDONALD CHARLES A JR
12-14899
MCELROY W N
12-15067 12-15071
MCFALL R
12-14493
MCGEE JAMES P
12-15013
MCGILL R M
12-14701
MCGINNIS F D
12-15079
MCGONNAGLE W J
12-15113
MCHENRY J R
12-14745
MCKENZIE D E
12-15062
MCKISSON R L
12-15062
MCLENDON J D
12-15176
MCMAHON J P
12-15074
MCNEESE L E
12-14676
MCNEESE W D
12-14639
MCREYNOLDS A W
12-14952 12-15051
12-15108
MEAD PAULINE A
12-14531
MECHAM W J
12-14706 12-14819
MELKONIAN E
12-15182
MENEGHETTI D
12-15024 12-15099
MEREDITH O M JR
12-14584
MERRILL J R
12-14772
MERRILL JOHN
12-14596
MERRYMAN J W
12-15110
MERTEN U
12-14826
MESROBIAN ROBERT P
12-14611
METTA V C
12-14484
METZ CHARLES F
12-14622 12-14641
METZ D J
12-14646
MEYER D D
12-14722
MEYER J E
12-15036
MEYER R A
12-15040 12-15121
MEYERS R A
12-15152
MICHAELSON SOL M
12-14510
MICHENER J W
12-14999
MILES F T
12-14704 12-15010
MILFORD R P
12-14690
MILLER C E
12-14925
MILLER G T
12-14904
MILLER N C
12-15065
MILLER P H JR
12-15157
MILNE G R
12-15088
MILVY P
12-14921
MIZE J P
12-14897
MOELLER D W
12-14534 12-14617
MOENCH R H
12-14788
MOH C C
12-14490
MONSON H O
12-15007 12-15073
12-15090
MONTGOMERY D J
12-14839
MOORE J G
12-14678
MOORE JAMES D
12-14679
MOORE M S
12-15180
MOORE R L
12-14748
MORAWETZ C S
12-14870
MORGAN A N JR
12-14639
MORGAN R H
12-14659
MORGAN K Z
12-14525
MORLEY D H
12-14760
MORRIS E T JR
12-15084
MORRIS P A
12-15122
MORROW ANDREW G
12-14582
MORTIMER ROBERT K
12-14508
MORTON ROY J
12-14751
MOSBURG E R JR
12-14951
MOSELEY ROBERT D JR
12-14543
MOSES VIVIAN
12-14486 12-14487
MOSKOWITZ B R
12-15034
MOXHAM ROBERT M
12-14789
MOYER R J
12-14930
MUELLER J
12-14820
MUFLLER M H
12-14915
MUGA M LUIS
12-14723
MUKAI T
12-14495
MULFORD R N P
12-14721
MULLER D R
12-15034 12-15064
MULLER H J
12-14494
MULLINS L J
12-14811
MULLINS W T
12-14623
MULRYAN R J
12-14562
MURRACH F W
12-14833
MURRAY J P
12-14726
MUSA R C
12-14702
MYTTON J W
12-14783

N

NACHTRIEB NORMAN H
12-14627
NEBEL R R
12-14511
NEIDIGH R V
12-14894
NEILL W J
12-14676
NEISSEL J P
12-14760
NELKIN M S
12-14952 12-14954
NELSON R D
12-14724
NELSON T C
12-14832
NEUMAN W F
12-14562
NEUVAR F W
12-14793
NEUZIL E F
12-15134
NEVITT M V
12-14823
NEWCOMB W A
12-14856
NEWTON T W
12-14725
NICHOLSON R R
12-15102
NIEMUTH W E
12-15016
NIGHTINGALE R E
12-14636
NILSON R
12-15016
NININGER ROBERT D
12-14784
NIXON V D
12-15110
NOHEL J A
12-14947
NOLAND ROBERT A
12-15046
NOLTING D D
12-14589
NOONAN THOMAS R
12-14499 12-14510
NOORDHOFF R H
12-15021
NORDHEIM L W
12-14956
NORDYKE ROBERT A
12-14586
NORTHROP JOHN A
12-15183
NORTHROP T G
12-14876
NORTON J J
12-14785
NORWOOD W D
12-14551
NOVICK M
12-15079 12-15127
NYER W F
12-15126

O

OBERG G C
12-14684
OBERMAN C P
12-14864 12-14885
ODA Y
12-14542
OESTMANN H J
12-14932
OGORZALY M J
12-14645
OKELLEY G D
12-14971
OKERS LAWRENCE K
12-14480
OKITA GEORGE T
12-14570
OKRENT DAVID
12-15023 12-15037
12-15079 12-15080
12-15102
OLSON R L
12-15028
OLSZEWSKI E R
12-14905
ORNDOFF J D
12-14987
ORTH CHARLES J
12-14764
OSHER J E
12-14897
OSTERGAARD P C
12-15005
OVADIA J
12-14485
OVERMAN RALPH T
12-14480
OWENS J E
12-15004
OXLEY C L
12-14852

P

PACK D H
12-14939
PAINE S H
12-15160
PAINTER L A
12-14671
PALLADINO R W
12-14858 12-14859
PALMER R F
12-14516
PAPROCKI S J
12-14825
PARKER F L
12-14750
PARKER GEORGE W
12-14972 12-15060
12-15139
PARKINS W E
12-15067
PARROTT J R
12-14691
PARSI F J
12-14673
PASHOS T J
12-14981 12-14983
PASSELL L
12-15074
PATRIARCA P
12-14836
PATTERSON C M
12-14761 12-15041
PATTERSON CLAIRE
12-14806
PATTERSON H W
12-14930
PATTERSON JOHN F
12-14908
PATTERSON MOREHEAD
12-14471
PATTON F S
12-14726
PAUL R S
12-15119
PEARCE D W
12-14761
PECSOK D A
12-14534
PEKEKNA R M
12-14620
PELLE R W
12-15133
PENDLETON ROBERT C
12-14553
PEREZ-MENDES VICTOR
12-14936
PERKINS R W
12-14516 12-14935
PERKINS WALTER A
12-14936
PERKINSON JESSE D JR
12-14482
PERLOW GILBERT J
12-15138
PERRY HARRY
12-15013
PETERSON P J
12-14640
PETERSON R E
12-15000
PETKUS E J
12-14706 12-14794
PETREE R
12-14931
PETRICK M
12-14757
PETROW H G
12-14729
PHELPS J P
12-14949
PHILLIPS H O
12-14709
PHILLIPS J A
12-14889 12-14897
PHILLIPS L
12-14930
PICKLESIMER M L
12-14837
PIERCE A P
12-14783
PIERCE D F
12-14902
PIGFORD THOMAS H
12-15050
PILKEY O H
12-14744
PIPES G W
12-14556
PITT W A
12-14983
PLATT A M
12-14744
PLUMMER A M
12-14990
PLZAK LOUIS F
12-14569
POLLARA F Z
12-14702
POLLOCK J W
12-14809
POLLYCOVE MYRON
12-14598
POLSON C F
12-14741
POMERANTZ R
12-15145
PON H G
12-14487
POPPENDIEK H F
12-15002
PORZEL F B
12-14479 12-14995
POVELITES J G
12-14607
POWELL C A
12-14740
POWELL F U
12-15106
POWELL J R
12-14704
POWELL ROBERT W
12-15109 12-15152
POWERS F L
12-14503
PRATER W K
12-14905
PREMACHANDRA R N
12-14556
PRESSMAN DAVID
12-14583
PRESSMAN JOEL J
12-14581
PRICE G A
12-14943
PRINCE W S
12-14983
PRITCHARD D W
12-14536
PRUS L R
12-15044
PYLE ROBERT V
12-14890

Q

QUASTLER H
12-14565 12-14592
QUINN W E
12-14855

R

RARIDEAU S W
12-14725
RASEMAN C J
12-15008
RASMUSSEN J O
12-14966
REARDAN JOHN
12-14596

REAVIS J G
12-14811
REDMAN W C
12-14912 12-15025
REED GEORGE W
12-14624
REID D G
12-14689
REIER M
12-14948
REIFFEL L
12-14926 12-14986
REINES F
12-14961
REITER T A
12-14645
REJALI ARRAS M
12-14801
REMICK F J
12-15056
REMLEY M E
12-15064
REVELLE ROGER
12-14763
REYNOLDS H L
12-15123
RHODEN V C
12-14791
RICE R F
12-15023 12-15079
RICHARDS F L
12-14828
RICHMAN D
12-15150
RICHTMYER R D
12-14910
RICKOVER H G
12-15129
RIDDELL R J
12-14876
RIECK H G
12-14911
ROBERTS J F
12-14876
ROBERTS J H
12-14912
ROBERTS L D
12-15139
ROBERTSON JAMES S
12-14540 12-14546
ROBINSON M T
12-15002
ROCHE T K
12-14896
ROCHLIN D S
12-14760
RODDIS LOUIS H JR
12-15061
RODGER W A
12-14706 12-14762
12-14812 12-14813
ROESCH W C
12-14615 12-15167
ROHDE R R
12-14991
ROHRMANN C A
12-14744
ROSE JOHN E
12-14610
ROSE M H
12-14870
ROSEN L
12-15150
ROSENBAUM J R
12-14672
ROSENBLUTH M N
12-14847 12-14849
12-14952
ROSENZWEIG N
12-14960
ROSENZWEIG WALTER
12-14922
ROSHOLT JOHN N
12-14777
ROSS-CLUNIS H A
12-15028
ROSSI HARALD H
12-14544 12-14922
ROSTOKER N
12-14849
ROTH LLOYD J
12-14571
ROTHSTEIN ASER
12-14603
ROUGH F A
12-14816
ROWLAND F S
12-14717
ROWLAND R E
12-14591
ROY R R
12-14916
RUBIN H
12-14870 12-14971
12-14881 12-.3174
RUBINI J P
12-14565
RUSSELL LIANE BRAUCH
12-14497
RUSSELL R T
12-14779
RUSSELL W L
12-14497
RUTHER W E
12-14768
RUTHERFORD HENRY A
12-15158
RYAN J L
12-14711
RYAN T M
12-15112
RYON A D
12-14677

S

SACKS JACOB
12-14561
SADOWSKI G S
12-14691
SAFONOV G
12-15091
SAILOR V L
12-15181
SALTMAN PAUL
12-14977
SANDERS RICHARD J
12-14582
SANDMEIER H A
12-15079
SANDS MATTHEW
12-14997
SANDUS O
12-14706
SAUL A M
12-15062
SAUNDERS N T
12-15115
SAUP A J
12-15065
SAVAGE H W
12-15027
SAWLE D R
12-15087
SAWYER G A
12-14879
SCADDEN E M
12-14720 12-15179
SCHABLASKE R V
12-15173
SCHAEFER H R
12-14763
SCHAIRER LLOYD A
12-14509
SCHALL PAUL
12-14992
SCHIEFER J D
12-14960
SCHMIDT W C
12-14746
SCHMITT P A
12-15135
SCHNEIDER R A
12-14626
SCHONER ROBERT T
12-15107
SCHONFELD F W
12-14810
SCHOOLAR JOSEPH C
12-14571
SCHORTMANN W E
12-14675
SCHRAIDT J H
12-14707 12-15014
SCHULER ROBERT H
12-14924
SCHULMAN JAMES H
12-14929 12-14991
SCHULTE H F
12-14722
SCHULTZ M A
12-15084
SCHULTZ W W
12-14760
SCHULZ W W
12-14733
SCHWARZ HAROLD A
12-14654
SCHWEIGERT R S
12-14488
SCHWEITZER D G
12-15121
SCHWENDIMAN L C
12-14616 12-14911
SCHWENNESEN J L
12-14682
SCOTT F A
12-14620
SCOTT F R
12-14852
SCOTT J H
12-14804
SCOTT J L
12-14836
SCOTT R C
12-14782
SCRIBNER GERTRUDE M
12-14505
SCULLY M
12-14578
SEABORG GLENN T
12-15140
SEAGREN H E
12-14699
SECREST E L
12-15120
SEEFELDT W B
12-14813
SEIGLE L L
12-15178
SEIM ORVILLE S
12-14759
SEITZ FREDERICK
12-15163
SELIGER H H
12-15166
SENVAR CEMIL B
12-14663
SERBER R
12-14938
SERVIZI J A
12-14513
SESONSKE ALEXANDER
12-14657
SHAFFER R L
12-14578
SHANK F M
12-14691
SHANSTROM RAYMOND T
12-15050
SHAPIRO S
12-14824
SHARP R A
12-15135
SHARRA ANTHONY J
12-14575
SHAW EDWARD I
12-14602
SHAW J C
12-14558
SHAWE DANIEL R
12-14776
SHEEHAN T V
12-15010
SHEFT I
12-14695
SHELLABARGER C J
12-14491
SHER R
12-15076
SHERMAN F G
12-14592
SHIFLETT C H
12-14658
SHILLING C W
12-14681
SHIPLEY E D
12-14845
SHONKA FRANCIS R
12-14610
SHORE F J
12-15181
SHOULTS D R
12-15011
SHOUPP W E
12-15055
SHREEVE W W
12-14594
SIDDALL T H III
12-14688
SIDHU S S
12-14915
SIEGEL SIDNEY
12-15039
SIEGEL STANLEY
12-14739
SIKKELAND TORRJORN
12-15141
SIKOV M R
12-14499
SIMANTON J R
12-15073
SIMMONS R E
12-15074
SIMMONS ERIC L
12-14529
SIMMONS GEORGE C
12-14776
SIMMONS W R
12-15079
SIMNAD M T
12-14827
SIMON ALBERT
12-14845 12-14865
SIMON M A
12-14581
SIMON N
12-14550
SIMPSON J W
12-15129
SIMPSON O C
12-15156
SIMS C T
12-14822
SINIZER D I
12-14833
SISSON R M
12-14738
SJORLON R
12-15137
SKAGGS LESTER S
12-14547
SLAUGHTER G G
12-14972
SLIWINSKI R A
12-14488
SLOAT P J
12-14684
SLUYTER M M
12-15090
SMELLIE R M JR
12-14670
SMILEY S H
12-14731 12-14732
SMITH A
12-15137
SMITH A R
12-14930
SMITH D F
12-14632
SMITH F A
12-15105
SMITH L
12-14876
SMITH R R
12-15049 12-15079
SMITH W G
12-14986
SMITH WILLIE W
12-14528
SNOODY L R
12-14698
SNYDER T
12-15119
SNYDER W A
12-14636
SOGO P R
12-14487
SOLDAT J K
12-14523
SOLMITZ FRANK
12-14918
SOLON L R
12-14521
SOMERVILLE A
12-14902
SPAINHOUR K A
12-14905
SPALDING T R
12-15073
SPAR IRVING L
12-14580
SPARROW ARNOLD H
12-14509
SPEH K C
12-14923
SPENCER HERTA
12-14552
SPINRAD B I
12-14841 12-14955
12-15052
SPITZER L
12-14887
SPRATT JAMES L
12-14570
STAEHLER U M
12-14476
STANNARD J N
12-14519 12-14599
STARR CHAUNCEY
12-15063
STASON F BLYTHE
12-14537
STAUSS V L
12-14560
STEARNS M
12-14852
STEHN J R
12-15169
STEHNEY ANDREW F
12-15138
STEIN J M
12-15108
STEIN S
12-15076
STEINDLER M J
12-14813
STEPHENSON MARY L
12-14568
STERN T W
12-14778
STEUNENBERG R K
12-14706 12-14711
12-14813
STEVENS J I
12-14762
STEVENSON C E
12-14689 12-14762
12-14903
STEVER K R
12-15171
STEWART H R
12-15116
STEWART J C
12-14945 12-14946
12-15035
STICKLEY F E
12-14546
STIEFF L R
12-14778
STITT R K
12-15064
STIX T H
12-14858 12-14859
12-14860
STOKES RICHARD H
12-15183
STOLLER S M
12-15088
STOLTZ F M JR
12-14703
STOLZ J F
12-15028
STONE C C
12-15046
STONE JOHN M
12-14869 12-14890
STONE P M
12-14906
STORM M L
12-15116
STOUGHTON R W
12-14978
STOVALL E J JR
12-14897
STRAHL ERWIN O
12-14792
STRATTON T F
12-14879
STRATTON W R
12-14993
STRUXNESS E G
12-14747 12-14761
STUART G W
12-14944
SUGIHARA T T
12-14770
SULLIVAN M F
12-14512
SUN SUNG HUANG
12-14578
SUNYAR A W
12-14913
SUSSKIND H
12-15008
SUYDAM BERGEN R
12-14853
SWANSON J L
12-14715
SWANSON V F
12-14737
SWANSON WILLIAM P
12-14899
SWEET WILLIAM H
12-14545
SWIATECKI WLADYSLAW J
12-14959
SWICK ROBERT W
12-14579
SWICKARD E O
12-15000
SYMON KEITH R
12-15147

T

TAINUTY S I
12-14931 12-14934
TALIAFERRO W H
12-14504
TANNER ALLAN B
12-14790
TAPLIN G V
12-14584
TARRICE RICHARD R
12-14472
TATE R F
12-14950

PERSONAL AUTHOR INDEX

TAVERNIER GUY
12-14984
TAYLOR G R
12-15111
TAYLOR J J
12-15021
TAYLOR LAURISTON S
12-14574
TAYLOR T R
12-15051 12-15104
TERRUTT T H Y
12-14513
TFITFL ROBERT J
12-14814
TERRELL C W
12-15071
TESZLER OTTO
12-15158
THALGOTT F W
12-15023 12-15079
12-15099
THAMER R J
12-15048
THAYER HAROLD E
12-14735
THAYER VICTOR R
12-14629
THEILACKER J S
12-15115
THIF J A
12-14757 12-15025
12-15038 12-15114
12-15119
THOMAS F J
12-15087
THOMAS G E
12-14975
THOMAS HENRY C
12-14753
THOMAS I D
12-14644 12-14724
THOMAS R L
12-14639 12-14640
THOMAS ROBERT G
12-14520
THOMAS T DARRAH
12-15140
THOMPSON R H
12-14630
THOMPSON R C
12-14512
THOMPSON STANLEY G
12-14723 12-15130
THOMPSON T J
12-14985
THOMSON J F
12-14578
THORN R J
12-14608
TIMLAKE W P
12-14947
TIPTON I H
12-14525
TORER F W
12-14687
TORIAS CORNELIUS A
12-14508
TODD J F
12-14651
TOLBERT F L
12-14486
TOLLIN GORDON
12-14487
TOMKINS FRANK S
12-14901
TOOLE R H
12-14796
TOPPEL R J
12-15024 12-15099
TRAGESER D A
12-14898
TREVORROW L
12-14706
TRILLING C A
12-14665 12-14989
TRIPLETT JOHN R
12-15083
TRURFY D K
12-15018
TSIEN W S
12-14484
TSIVOGLOU E C
12-14752
TUCK J L
12-14889
TUCKFIELD R G JR
12-14852
TURKEVICH ANTHONY
12-14624
TURKEVICH JOHN
12-14612
TURNBULL H F
12-15044
TURNER C W
12-14556

U

ULRICH A J
12-14850
UNTERMYER S
12-15092
UPCHURCH T R
12-14730
UPTON A C
12-14530

V

VAN DYKE D C
12-14600
VAN LINT VICTOR A J
12-15157
VAN MIDDLEWORTH L
12-14538
VAN NORTON R
12-14910
VAN OMMESLAGHE BERNARD
12-15050
VAN SLYKE D D
12-14594
VANDENBOSCH ROBERT
12-15136
VANDERBEEK J W
12-14526
VARGA R S
12-14953
VAUGHN W W
12-14791
VERBER F
12-15073
VERBINSKI V V
12-14760
VINE J D
12-14737
VISALLI F I
12-14596
VISKANTA R
12-14757
VOGEL G J
12-14706
VOGEL H H JR
12-14502
VOGEL R C
12-14706 12-14713
12-14813
VOGELSANG W F
12-15021
VOGLER S
12-14819
VOIGT ADOLF F
12-14809
VON HALLE E
12-14697
VOORHEES R G
12-15026
VOORHIS A D
12-15112

W

WARER JAMES T
12-14767
WACHSPRESS E L
12-14906
WACHTER J W
12-15176
WAGNER HARVEY A
12-15081
WAGNER J J
12-14961
WAGNER P
12-14637
WAIDE C H
12-15008
WAKEFIELD K E
12-14858
WALKER R M
12-15163
WALLACE R
12-14930
WALLIN W R
12-15114
WALLING H T JR
12-14714
WALSH P D
12-15042
WALTER HARRY
12-14563
WARD F R
12-15088
WARE W R
12-14991
WASSERMAN R H
12-14559
WATERBURY GLENN R
12-14622
WATSON F C
12-14526
WEATHERHEAD R J
12-14757
WEAVER C H
12-14894
WEBB R R
12-14503
WEBB R L
12-14716
WEBSTER J W
12-15057
WEEKS ALICE D
12-14807
WEEKS J R
12-15121
WEHMEYER D R
12-15120
WEINBERG A M
12-15018
WEINSTOCK BERNARD
12-14634
WEINSTOCK E V
12-14943
WEISSKOPF VICTOR F
12-14964
WELCH GRAEME P
12-14508
WELSH L
12-15092
WESCOTT E M
12-14804
WESSEL F W
12-14788
WETHINGTON JOHN A JR
12-14633
WHARTON C B
12-14875
WHATLEY M E
12-14690
WHEELWRIGHT E J
12-14711
WHIPPLE G HOYT
12-14475
WHITE J C
12-14705
WHITHAM G K
12-15049
WHITMAN A
12-14729
WHITMAN CHARLES I
12-14696
WHITMAN WALTER G
12-14483
WHITTEMORE W L
12-14952
WICK G J
12-14644 12-14832
WILLIAMS A H
12-14892
WILLIAMS CLARKE
12-15107
WILLIAMS D V P
12-15120
WILLIAMS R G JR
12-15034
WILLIAMS T E
12-14647
WILLIS A H
12-15154
WILMARTH V R
12-14785
WILSON A S
12-14693
WILSON E E
12-14791
WILSON J C
12-15161
WILSON P E
12-15034 12-15067
WILSON R H
12-14551
WILSON W E
12-15066
WIMETT T E
12-14987
WIMMER P E
12-15064
WINING E A
12-15114
WINCHESTER R S
12-14719
WINSCH I O
12-14812
WINTER C C
12-14584
WISWALL P H
12-14704
WITHROW ROBERT R
12-14490
WITKOWSKI E J
12-14751
WITTELS M C
12-14765
WITTING L A
12-14488
WOLFE A
12-14910
WOLFE R
12-14981 12-14983
WOLFF R A
12-15115
WOLFGANG RICHARD
12-14664
WOLKOFF J
12-14812
WOOD DAVID P
12-15058
WOOD H G
12-14573
WOODMAN W C
12-15055
WOODMANSEE W C
12-14794
WORF D L
12-14474
WRIGHT M L
12-14695 12-14817
WRIGHT R E
12-14868
WRIGLEY E K
12-14689
WROUGHTON D H
12-14980
WYCKOFF H O
12-14931
WYMAN M F
12-14961

Y

YAMAZAKI J
12-14493
YEVICK J G
12-15125
YOSIM S J
12-15062

Z

ZAMECNIK PAUL C
12-14568
ZBAROSKI E L
12-15103
ZEGLER S T
12-14823
ZILA A V
12-14521
ZIMMERMAN R L
12-14977
ZINN W
12-14982
ZINN W H
12-15061
ZOREL W
12-15133
ZWEIFEL P F
12-14946 12-14947

NUMERICAL INDEX OF REPORTS

This is a list of reports abstracted in this issue of *Nuclear Science Abstracts*, with the corresponding abstract number reference.

The report number codes listed below apply to AEC reports unless otherwise designated. Other codes are listed as British, Canadian, or Non-AEC. Those codes marked Misc. are used for both AEC and non-AEC reports. For a complete description of all report number codes used by the AEC, see TID-85, *Report Number Series Used by the Technical Information Service in Cataloging Reports*. September 1957. 112p. $3.00 (OTS). Some reports appear under more than one code designation and wherever practical all report numbers are listed in this index.

Report No.	Abstract No.	Report No.	Abstract No.	Report No.	Abstract No.	Report No.	Abstract No.
A/CONF.15/P		A/CONF.15/P		A/CONF.15/P		A/CONF.15/P	
344	12-14845	418	12-14986	519	12-14686	628	12-15032
345	12-14846	419	12-14987	520	12-14687	629	12-15033
346	12-15142	420	12-14988	521	12-14688	630	12-15034
347	12-14847	421	12-14989	522	12-14656	631	12-14946
348	12-14848	422	12-14990	523	12-14731	632	12-15035
349	12-14849	423	12-14991	524	12-14630	633	12-14908
350	12-14850	424	12-14992	525	12-14732	634	12-14947
351	12-14851	426	12-14939	526	12-14689	635	12-14948
352	12-14852	427	12-15176	528	12-14810	636	12-15036
353	12-14843	428	12-14517	529	12-14811	637	12-15037
354	12-14853	430	12-14518	530	12-14719	638	12-15038
355	12-14854	431	12-14993	531	12-14639	639	12-14907
356	12-14855	433	12-14994	532	12-14640	642	12-14965
357	12-14856	434	12-14995	533	12-14641	643	12-15179
358	12-14857	435	12-14996	534	12-14733	644	12-14720
359	12-14858	436	12-14997	535	12-14690	645	12-15180
360	12-14859	437	12-14998	536	12-14691	646	12-14913
361	12-14860	439	12-14726	537	12-14692	647	12-14914
362	12-14861	440	12-14999	538	12-14812	648	12-15181
363	12-14862	442	12-14727	539	12-14813	649	12-15149
364	12-14863	443	12-14472	540	12-14814	650	12-14966
365	12-14864	445	12-15000	541	12-15014	651	12-14959
366	12-14865	447	12-15001	542	12-14734	652	12-15130
367	12-14866	448	12-15002	543	12-14642	655	12-15182
369	12-14867	449	12-15003	544	12-14693	659	12-15183
372	12-14868	452	12-15004	545	12-14815	660	12-15131
373	12-14869	453	12-15005	546	12-14694	662	12-14967
374	12-14870	455	12-15006	590	12-15015	663	12-14968
376	12-14871	457	12-14605	591	12-15016	664	12-14607
378	12-14872	458	12-15007	592	12-15017	665	12-15132
379	12-14873	459	12-15008	593	12-15018	666	12-14969
380	12-14874	460	12-15009	594	12-15019	667	12-14970
381	12-14875	461	12-15010	595	12-15020	668	12-15150
383	12-14876	462	12-15152	596	12-15021	670	12-15133
385	12-14877	465	12-15011	596(Add.1)	12-15022	671	12-14949
386	12-15174	466	12-15012	597	12-14912	672	12-14971
387	12-14878	495	12-15013	598	12-15023	673	12-14972
388	12-14513	496	12-14668	599	12-15024	675	12-14973
389	12-14744	497	12-14669	600	12-15025	677	12-15134
390	12-14514	498	12-14728	601	12-14943	678	12-15135
391	12-14515	499	12-14670	602	12-14735	679	12-14765
392	12-14553	500	12-14671	604	12-15026	680	12-14915
393	12-14516	501	12-14672	605	12-15027	685	12-14974
394	12-14911	502	12-14673	608	12-15028	687	12-14975
395	12-14745	503	12-14729	610	12-15029	688	12-15136
397	12-14746	504	12-14674	611	12-14606	690	12-15137
401	12-14554	505	12-14675	612	12-15153	691	12-15138
402	12-14555	506	12-14676	613	12-14764	693	12-14960
403	12-14770	508	12-14730	614	12-14636	694	12-14916
404	12-15164	509	12-14677	615	12-15177	695	12-14839
406	12-14539	510	12-14678	616	12-15154	696	12-14817
410	12-14980	511	12-14679	617	12-15030	697	12-14695
411	12-14771	512	12-14680	618	12-15178	698	12-14818
412	12-14772	513	12-14681	619	12-15155	699	12-14767
413	12-14981	514	12-14682	621	12-15156	700	12-14950
414	12-14982	515	12-14683	622	12-14816	701	12-14721
415	12-14983	516	12-14684	624	12-14944	702	12-14637
416	12-14984	517	12-14809	625	12-15031	705	12-15039
417	12-14985	518	12-14685	627	12-14945	706	12-14819

NUMERICAL INDEX OF REPORTS

Report No.	Abstract No.	Report No.	Abstract No.	Report No.	Abstract No.	Report No.	Abstract No.
A/CONF.15/P		A/CONF.15/P		A/CONF.15/P		A/CONF.15/P	
707	12-14820	802	12-15157	897	12-14497	1069	12-15159
708	12-15040	803	12-14827	898	12-14530	1071	12-15169
709	12-14821	805	12-14646	900	12-14498	1072	12-14978
710	12-14736	806	12-14488	902	12-14499	1073	12-14747
712	12-14822	807	12-14485	903	12-14500	1074	12-15060
713	12-14823	808	12-14659	904	12-14547	1075	12-15061
714	12-14768	809	12-14840	906	12-14501	1076	14-14476
715	12-14608	811	12-14556	907	12-14502	1077	12-15062
717	12-14696	812	12-14557	908	12-14503	1078	12-15063
718	12-14627	813	12-14558	909	12-14504	1079	12-15064
719	12-14697	815	12-14489	910	12-14591	1080	12-15065
720	12-14755	816	12-14559	911	12-14505	1081	12-14830
721	12-14900	818	12-14647	912	12-14506	1082	12-15066
722	12-14609	819	12-14760	913	12-14592	1128	12-14663
723	12-14698	820	12-14560	914	12-14620	1403	12-14654
725	12-15139	821	12-15158	915	12-14660	1425	12-15171
726	12-15143	822	12-14540	916	12-14649	1426	12-14664
729	12-14917	824	12-14716	917	12-15172	1427	12-14962
730	12-14918	825	12-14723	918	12-14621	1428	12-14766
730(Rev.1)	12-14919	826	12-14611	920	12-14650	1429	12-15140
732	12-14936	827	12-14926	922	12-14631	1430	12-14769
733	12-14920	828	12-14541	923	12-14651	1431	12-14532
734	12-14937	829	12-15168	925	12-15048	1433	12-14831
735	12-14976	830	12-14905	926	12-14622	1434	12-14704
736	12-15144	831	12-14699	927	12-14623	1538	12-14881
737	12-14938	832	12-14700	928	12-14718	1540	12-14952
738	12-14519	833	12-14473	930	12-14632	1541	12-14953
739	12-14520	834	12-14838	932	12-14701	1542	12-14533
740	12-14521	835	12-14561	934	12-14612	1543	12-15067
741	12-14522	836	12-14562	937	12-14633	1544	12-14842
742	12-15165	837	12-14563	940	12-14613	1545	12-14598
743	12-14523	839	12-14564	941	12-14667	1547	12-15068
744	12-14921	840	12-14565	942	12-14634	1548	12-14739
745	12-15041	841	12-14618	943	12-15173	1549	12-15069
746	12-14922	842	12-14566	945	12-14901	1550	12-14705
747	12-14923	843	12-14486	946	12-15049	1551	12-15070
750	12-15166	845	12-14567	948	12-14661	1552	12-14706
751	12-14524	846	12-14568	949	12-14652	1761	12-14756
752	12-14951	847	12-14569	951	12-14653	1762	12-14927
753	12-14610	848	12-14570	952	12-14662	1764	12-14844
755	12-15167	849	12-14571	953	12-14624	1765	12-14882
756	12-14615	851	12-14572	954	12-14625	1766	12-15071
757	12-14525	852	12-14573	1008	12-14552	1767	12-14761
758	12-14526	854	12-14574	1009	12-14908	1768	12-14748
759	12-14616	855	12-14575	1010	12-14828	1769	12-14655
760	12-14722	856	12-14576	1015	12-14738	1770	12-14785
761	12-14924	857	12-14577	1016	12-15050	1771	12-15146
762	12-14925	858	12-14619	1017	12-15051	1772	12-14786
763	12-15042	859	12-14648	1018	12-14841	1773	12-14534
765	12-14551	860	12-14578	1019	12-15052	1775	12-14635
768	12-14773	861	12-14579	1023	12-14474	1776	12-14832
769	12-14774	862	12-14784	1024	12-14702	1777	12-15072
770	12-14775	863	12-14580	1025	12-14879	1778	12-14638
771	12-14776	865	12-14581	1026	12-14961	1779	12-14665
772	12-14777	866	12-14582	1028	12-15053	1780	12-14833
773	12-14778	869	12-14583	1029	12-14593	1781	12-14834
774	12-14779	870	12-14584	1030	12-14724	1782	12-15073
775	12-14780	871	12-14585	1031	12-14480	1783	12-15074
776	12-14781	872	12-14542	1032	12-14829	1784	12-14507
778	12-14782	874	12-14543	1034	12-15054	1785	12-14835
779	12-14737	875	12-14544	1036	12-14977	1787	12-14482
780	12-14783	876	12-14586	1037	12-14594	1789	12-14942
784	12-14824	877	12-14587	1038	12-15055	1790	12-14883
785	12-15043	879	12-14588	1040	12-14595	1794	12-14928
787	12-15044	880	12-14589	1041	12-15056	1795	12-14707
788	12-14825	881	12-14545	1042	12-14481	1796	12-14535
789	12-14826	883	12-14546	1043	12-14475	1829	12-14643
790	12-15045	884	12-14490	1044	12-15057	1830	12-14708
791	12-15046	885	12-14491	1045	12-14902	1832	12-14709
792	12-15047	886	12-14590	1047	12-15058	1833	12-14636
793	12-15145	887	12-14527	1057	12-14596	1834	12-14604
794	12-14657	888	12-14492	1058	12-14597	1835	12-14536
795	12-14645	889	12-14528	1060	12-14531	1836	12-14904
796	12-14617	891	12-14493	1063	12-14628	1838	12-15075
797	12-14658	893	12-14494	1064	12-14880	1839	12-14954
798	12-14717	894	12-14529	1065	12-14629	1840	12-14740
799	12-14484	895	12-14495	1066	12-14703	1841	12-15076
800	12-14898	896	12-14496	1068	12-15059	1842	12-15077

Report No.	Abstract No.
A/CONF.15/P	
1843	12-15078
1844	12-14508
1845	12-15079
1847	12-14955
1848	12-15080
1850	12-15081
1855	12-15184
1858	12-15082
1859	12-14929
1861	12-14884
1866	12-14666
1867	12-14940
1869	12-15083
1873	12-15084
1875	12-14885
1876	12-14886
1878	12-15085
1879	12-15086
1881	12-14979
1882	12-14930
1883	12-14710
1884	12-15087
1885	12-15088
1889	12-14741
1890	12-15160
1891	12-15089
1892	12-15090
1893	12-15091
1898	12-14599
1899	12-14600
1901	12-14601
1903	12-14644
1904	12-14787
1906	12-14788
1907	12-14789
1908	12-14790
1909	12-14791
1910	12-14792
1911	12-14793
1912	12-14794
1915	12-14711
1917	12-14795
1919	12-14796
1920	12-14797
1921	12-14798
1922	12-14762
1923	12-15092
1925	12-15093
1926	12-15094
1927	12-14931
1929	12-15095
1930	12-14712
1931	12-14799
1932	12-14800
1933	12-14801
1934	12-14802
1935	12-14803
1936	12-14804
1978	12-15161
1979	12-14805
1980	12-14806
1983	12-14757
1986	12-14903
1987	12-14742
1988	12-14956
1990	12-14836
1993	12-14837
1996	12-14602
2001	12-14932
2003	12-14603
2004	12-14749
2008	12-14754
2009	12-14933
2010	12-15096
2014	12-14934
2015	12-14899
2019	12-14807
2021	12-15097
2156	12-15098
2157	12-14758
2158	12-14759
2160	12-15099
2161	12-14477
2162	12-15100
2163	12-14478
2164	12-15101
2165	12-15102
2167	12-15103
2170	12-14887
2172	12-14509
2177	12-15104
2178	12-14479
2246	12-14487
2247	12-14725
2259	12-14471
2288	12-14941
2291	12-15105
2292	12-14888
2324	12-14510
2348	12-14889
2349	12-14890
2351	12-14750
2352	12-14537
2354	12-14751
2355	12-15107
2356	12-15106
2357	12-15175
2358	12-14891
2359	12-14752
2364	12-15108
2366	12-15109
2371	12-14548
2372	12-15110
2373	12-15111
2374	12-14511
2375	12-14957
2376	12-15112
2377	12-14935
2378	12-15113
2379	12-15114
2380	12-15115
2381	12-15116
2382	12-14512
2384	12-15162
2385	12-15163
2386	12-14909
2387	12-15117
2388	12-14713
2390	12-15170
2391	12-15118
2392	12-14483
2393	12-14963
2394	12-14892
2395	12-14893
2396	12-14894
2399	12-14964
2400	12-15147
2401	12-14549
2402	12-15119
2403	12-14550
2404	12-14743
2405	12-15120
2406	12-15121
2407	12-15122
2408	12-15123
2409	12-14714
2410	12-14808
2420	12-15124
2426	12-15151
2427	12-15125
A/CONF.15/P	
2428	12-15126
2429	12-14715
2430	12-14896
2431	12-14763
2432	12-15148
2437	12-15127
2440	12-15141
2441	12-14733
2446	12-14896
2447	12-15128
2462	12-15129
2478	12-14614
2488	12-14807
2489	12-14910
2494	12-14958
2497	12-14538
AMRL	
349	12-14840
HASL	
25	12-14821
ISC	
1016	12-15143
1018	12-14809
1031	12-14621
NYO	
7907	12-14792
TID	
7549(Pt.2)	12-15060
UCRL	
3981	12-14486
3982	12-14650
3985	12-14567
3989	12-15140
3992	12-14509
3995	12-14500
3996	12-14493
5021	12-14710
5028	12-15149
5038	12-15130
5159(Rev.)	12-15074
5175	12-15123
5220	12-14958
8083	12-14527
8292	12-15141
WAPD-T	
763	12-15115
WIN	
89	12-14675

DEPOSITORIES OF USAEC REPORTS IN LIBRARIES OUTSIDE THE U.S.

The libraries listed below maintain collections of unclassified U. S. Atomic Energy Commission reports for reference use.

ARGENTINA
Buenos Aires, Comisión Nacional de Energía Atómica

AUSTRALIA
Canberra, Australian National Library
Sutherland, New South Wales, Australian Atomic Energy Commission

AUSTRIA
Vienna, Institut für Radiumforschung der Oesterreichischen Akademie der Wissenschaften
Vienna, International Atomic Energy Agency

BELGIUM
Brussels, Centre d'Etudes pour les Applications de l'Energie Nucléaire

BRAZIL
Rio de Janeiro, Instituto Brasileiro de Bibliografia e Documentacao

BURMA
Rangoon, Union of Burma Applied Research Institute

CANADA
Ottawa, National Research Council Library

CEYLON
Colombo, University of Ceylon

CHILE
Santiago, Ministerio de Relaciones Exteriores

COLOMBIA
Bogotá, Instituto Colombiano de Asuntos Nucleares

COSTA RICA
San Pedro, University of Costa Rica Library

CUBA
Havana, Comisión de Energía Nuclear de Cuba

DENMARK
Risö, Danish Atomic Energy Commission

DOMINICAN REPUBLIC
Ciudad Trujillo, National Palace

EGYPT
Cairo, Atomic Energy Commission

ENGLAND
Birmingham, Central Library
Bristol, Central Library
Kingston upon Hull, Central Library
Leeds, Central Library
Liverpool, Central Library
London, Central Library, Acton
London, Science Museum Library, South Kensington
Manchester, Central Library
Newcastle upon Tyne, Central Library
Nottingham, Public Libraries
Sheffield, Central Library

FINLAND
Helsinki, Teknillisen Korkeakoulun Kirjasto

FORMOSA (TAIWAN)
Taipei, National Tsing Hua University Library

FRANCE
Gif-sur-Yvette, Centre d'Etudes Nucléaires de Saclay
Paris, Organization for European Cooperation, Nuclear Energy Library

GERMANY
Berlin, Institut für Kernforschung Berlin
Munich, Technische Hochschule, Bibliothek

GREECE
Athens, Greek Atomic Energy Commission

GUATEMALA
Guatemala Comisión Nacional de Energía Nuclear

HAITI
Port au Prince, University of Haiti

ICELAND
Reykjavik, University of Iceland, Atomic Energy Library

INDIA
Bombay, Department of Atomic Energy

IRAQ
Baghdad, The Ministry of Development, Atomic Energy Division

IRELAND
Dublin, University College

ISRAEL
Tel Aviv, Israel Atomic Energy Commission

ITALY
Rome, Comitato Nazionale Ricerche Nucleari

JAPAN
Tokyo, Science Section, Diet Library

KOREA
Seoul, Atomic Energy Commission, c/o Ministry of Education

LEBANON
Beirut, American University

LUXEMBOURG
Luxembourg, Ministry of Transport and Electricity

MEXICO
Mexico, D.F., Comision Nacional de Energía Nuclear

NETHERLANDS
The Hague, Reactor Centrum Nederland

NEW ZEALAND
Wellington, Department of Scientific and Industrial Research

NORTHERN IRELAND
Belfast, Department of Industrial and Forensic Science

NORWAY
Lillestrøm, Institutt for Atomenergi

PAKISTAN
Karachi, Atomic Energy Commission

PERU
Lima, Biblioteca Nacional

PHILIPPINE REPUBLIC
Manila, Philippine Atomic Energy Commission

PORTUGAL
Lisboa, Junta de Energía Nuclear

SCOTLAND
Glasgow, Mitchell Library

SPAIN
Madrid, Junta de Energía Nuclear

SWEDEN
Stockholm, Atomenergi AB

SWITZERLAND
Geneva, United Nations Library
Zurich, Institut für Physik, Eidg. Technische Hochschule

THAILAND
Bangkok, Office of the Thai Atomic Energy Commission, Department of Science

TURKEY
Ankara, Turkish Atomic Energy Commission, Atomic Energy Library

UNION OF SOUTH AFRICA
Pretoria, Library and Information Division, South African Council for Scientific and Industrial Research

UNITED NATIONS
New York, N. Y., U.N. Headquarters

URUGUAY
Montevideo, Universidad de Montevideo

VENEZUELA
Caracas, Instituto Venezolano de Neurologia e Investigaciones Cerebrales

YUGOSLAVIA
Belgrade, Federal Nuclear Energy Commission

LEGAL NOTICE

The AEC reports listed in this document are accounts of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in these reports, or that the use of any information, apparatus, method, or process disclosed in these reports may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in these reports.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

UNITED STATES
GOVERNMENT PRINTING OFFICE
DIVISION OF PUBLIC DOCUMENTS
WASHINGTON 25, D. C.

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE TO AVOID
PAYMENT OF POSTAGE, $300
(GPO)

TECHNICAL PROGRESS REVIEWS

The U. S. Atomic Energy Commission, Technical Information Service, publishes an unclassified series of Technical Progress Reviews which provide concise summaries of current atomic developments. Issued quarterly, each of these Technical Progress Reviews digests and evaluates the latest findings in a specific area of nuclear technology and science. The Reviews also report on technology developed in military reactor and other classified AEC programs to the extent that the technology can be dissociated from sensitive military and production data.

The three journals currently published in this series are:

Power Reactor Technology, Walter H. Zinn and associates, General Nuclear Engineering Corporation

Reactor Fuel Processing, Stephen Lawroski and associates, Chemical Engineering Division, Argonne National Laboratory

Reactor Core Materials (covering solid material developments), R. W. Dayton, E. M. Simons, and associates, Battelle Memorial Institute

Each journal may be purchased by subscription (domestic, $2.00 a year; foreign, $2.50 a year) or by individual issue (55¢) from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.